Eng. Lib.

SCIENTIFIC AMERICAN SUPPLEMENT. No. 1870

Entered at the Post Office of New York, N. Y., as Second Class Matter.

Published weekly by Munn & Co., Inc., at 361 Broadway, New York.

Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York.

Scientific American, established 1845.
Scientific American Supplement, Vol. LXXII., No. 1870.

NEW YORK, NOVEMBER 4, 1911.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

Fisherman Casting the Net on the Sea of Galilee.

CASTING THE NET [See page 296].

Life in Other Worlds*

Which of the Celestial Spheres Are Inhabitable?

By H. C. Wilson

The question asked of the astronomer, more frequently perhaps than any other by the average visitor to an observatory, is that concerning the "man in the moon." Though jokingly asked in general, and sometimes in all seriousness, it always implies a serious question, which naturally arises in the mind of one who thinks on things celestial, concerning the possibility of life like our own in other worlds. Are all the planets which circle around the sun, or any of them, the abodes of living, sentient beings? Are those beings like ourselves? Are they engaged in similar pursuits? Do they till the soil, sow and reap, buy and sell and get gain? Have they learned men, prying into the secrets of the universe with microscope and telescope? Are they looking down at us and wondering whether on this little earth we know as much as they do? Or, among the millions of orbs which sweep through limitless space, is the little world on which we stand the only one which has been honored by the Creator with the creation of "man in his own image"?

Fruitless questions these, you may say, which it is impossible to decide. True. Still, these are things we would like to know and we shall be justified in throwing all the light we can upon them. Of late the studies of the planet Mars have drawn attention to the similarity of its physical condition to that of the earth, and there have been suggestions of methods of interplanetary communication. The newspapers a few years ago circulated reports to the effect that a certain astronomer had seen lights flashing from Mars in such a manner as to suggest to him a system of signals; in other words, that the Martians were attempting to telegraph to the inhabitants of the earth, or some other planet, after the manner of our army signal service. Though this was all a hoax, the thought has been taken up, partly in jest, partly in earnest, and schemes have been suggested for signaling back to the Martians by series of flashes from powerful condensers at the extremities of a great triangle upon the earth's surface. One lady was so impressed by these suggestions that at her death she left the sum of 25,000 francs to the Institut de France, to be use in carrying out the experiments. Of course nothing could come from such attempts, and I do not suppose they will ever be made, but the thoughts are interesting and might be made the basis of a popular novel.

Into the *a priori* arguments in favor of or against the belief that the other planets are inhabited I have not time to enter.

The elaboration of such views would be exceedingly interesting, but I must confine myself to the discussion of the facts, which have been derived from observations with telescope and spectroscope, concerning the physical condition of the planets, and their bearing upon the question of habitability. I say habitability, for I do not think we shall ever be able to say positively that any of the planets *are actually inhabited*. We shall by no increase of magnifying and defining power of telescopes ever be able to actually *see* the inhabitants. This is not because we have reached the limit of magnifying power, but because of the great turbulent ocean of atmosphere through which we must look, and which is almost incessantly in motion, bending and intermingling the rays of light which come to us, so that the minute details of a planet's surface are hopelessly blurred. The more we magnify them the worse they are blurred. On exceedingly rare occasions this sea of air quiets down and permits the astronomer to use the full power of his instrument. The astronomer is happy if at these times he is free to devote his attention to those objects which are most attractive to the sight. Occasionally such opportunities come to us at Goodsell Observatory. One in particular I call to mind. Visitors were present, and soon the clouds came over, but in the few minutes granted to us we saw minuter detail in the depths of some of those giant craters in the moon than we had ever seen before. Fine, however, as these details were, they were far too coarse to indicate the presence of men or elephants, or even individual houses and trees. With the highest power we can use on our 16-inch telescope, the moon is brought within 150 miles, i. e., its apparent size in the telescope is as large as it would be to the naked eye if the moon were actually one hundred and fifty miles away. The great Lick telescope in its favorable position on a mountain, above the worst of the atmospheric disturbances, will at best bring the moon within sixty miles. You know how little can be seen at that distance. A man, to be seen with the unaided eye, must be within ten miles distance. Theoretically, a telescope could be constructed of sufficient power to bring the moon within ten miles, but at the summit of the highest mountain on the earth, there would still be air enough (as well as sufficient lack of air) to prevent its use. We must then give up all hope of seeing living beings on the moon, our nearest neighbor, much more so on the other planets.

Inquiring into the physical conditions of the planets, as suitable to the sustenance of life or not, we find first upon the moon *no air*. At least the atmosphere is thinner than that in the most perfect vacuum which we can produce by means of an air pump. The rays of light from stars, when the moon passes them, suffer no change, either of intensity or direction, until they are instantly cut off by the solid edge of the moon. There are no clouds and no water. Air and water have apparently all been absorbed into the solid crust of our satellite. Without air and water, no vegetation can exist. There is no soil other than volcanic ashes. The surface is exceedingly rough and broken, the greater portion completely covered with crater rings and cones, lava ridges and mountains. Great yawning cracks and chasms abound, thousands of yards wide and of unknown depth. The temperature is intensely cold. The rays of the sun beat down fiercely upon the surface unrestrained by the blanket of air and vapor which on the earth both tempers and retains the heat, but the absence of this blanket allows the heat on the moon to be almost immediately radiated into space. According to the most recent investigations, the temperature of the lunar surface even during the long day (fourteen of our days) of continuous sunshine does not rise above the freezing point. And during the equally long night it must fall appallingly low. Surely this is not the place to look for life like ours.

The sun, I suppose, may be left out of consideration. A ball of gas, having a surface temperature estimated at about 10,000 deg. F., would not be likely to be a comfortable place to live. Yet the theory has been entertained, by so great an authority as Sir William Herschel, that there might be a cool body within the sun, protected in some way from the intense heat of the exterior, so that life would be possible and comfortable. What kind of an envelope could possibly be sufficient to protect the interior from the immense radiation of the exterior, which is found to be about 10,000 horse-power per square foot, has not been satisfactorily explained.

Passing outward from the sun, the first planet we come to is Mercury. Until recently but little was known of the physical condition of this planet. Its orbit is so near the sun that observations of its surface are obtained only with difficulty and under unfavorable circumstances. In 1881-2, however, Schiaparelli succeeded, by midday observations in the transparent sky of Italy, in identifying certain markings on Mercury's surface which led him to the conclusion that the planet rotates upon its axis in the same time that it revolves about the sun, thus keeping always the same side toward the sun. More recently this conclusion has been verified by Lowell's observations at Flagstaff, Arizona, and it is probably to be accepted as a fact, although it is not yet admitted by all astronomers. If it be true, this fact has an important bearing upon the subject we are discussing. If the planet always keeps the same side toward the sun, there will be on the one hemisphere eternal day, on the other everlasting night. We can imagine what would be the effect upon the earth if the sun were to stop its diurnal course through the sky and become stationary near the zenith. Without the alternation of day and night, a continuous noon-day sun boiling down fiercely year after year would raise the temperature to a frightful height. Multiply the intensity of the rays of the tropical midsummer sun by nine and you will have some idea of those which beat down upon the sunward side of Mercury. On the other side would be the opposite extreme, unbroken night and a temperature practically as low as that of space. On the margin of the two hemispheres would be a zone 47 degrees wide which would be alternately in sunshine and in darkness in the period of the planet's revolution, eighty-eight days. The sun does not stand stock still in the sky, but nods back and forth, east and west, through an arc of 47 degrees, because of the planets varying speed in its quite elliptic orbit, while its rotation is uniform. We perhaps might suppose that the middle portion of this zone of alternate sunlight and darkness might be endurable by beings like ourselves, so far as heat and cold are concerned, but it is probable that Mercury, like the moon, has little if any air and water. Having only one twenty-first of the mass of the earth, Mercury's gravitation is theoretically insufficient to retain much of an atmosphere, and according to Lowell's observations, there is no visible evidence of any, for the markings which are seen are unobscured by haze or cloud on the planet. We must, therefore, conclude that Mercury is not habitable.

Next outward from the sun we come to Venus. In size and density this planet is very like the earth, and we might expect here, if anywhere upon the planets, we should find conditions suitable for life like our own. Until recently the rotation period was thought to be almost the same as that of the earth, so that she would have the same alternation of day and night, and the fact that what markings are seen are of the dimmest, vaguest sort, argues that a dense atmosphere, perhaps filled with clouds, covers the planet. In 1889, however, Schiaparelli came to the conclusion that Venus, like Mercury, keeps the same side always toward the sun, rotating once in exactly the same time in which she completes her circuit around the sun. Lowell's more recent observations confirm this view, and spectrograms of the planet taken at Flagstaff tend to establish the fact of very slow rotation. We may, however, question the validity of a proof which depends upon spectrograms taken in midday, when the sky spectrum, i. e., the spectrum of sunlight reflected by our own atmosphere, is superposed upon that of the planet, and masks the slight inclination which the planet's rotation might produce in the spectral lines.

The orbit of Venus is very nearly circular, so that, if the planet rotates exactly once in each revolution around the sun, there is very little libration in longitude, and the conditions upon the sunward side and the side opposite must be even more contrasted and constant than upon Mercury. Prof. Lowell points out that the atmospheric currents would be practically constant, the lower currents being away from the point directly beneath the sun to the point directly opposite. One effect of these conditions would be to continually carry away the moisture from the sunward hemisphere and deposit it in the form of snow and ice on the dark hemisphere. The low temperature prevailing there would cause the moisture to be frozen and so prevented largely from returning. This process kept up from age to age would finally deplete one hemisphere of its water and cover the other with a permanent coat of ice. Thus Venus, if these things are true, is an even more undesirable place of abode than Mercury.

We have not been very successful, thus far, in our attempt to find a place of comfortable abode away from the earth. Let us try Mars next. Here we first find positive signs of similarity to the earth. The atmosphere of Mars is much less dense than that of Venus or that of the earth, and much more of permanent detail of surface may be seen than upon any other planet. We see here large areas of bluish green, which used to be called seas and oceans, but which are now thought to be regions where vegetation is abundant. Other large areas, covering more than half of the surface of Mars, are of a reddish orange color, and are thought to be great deserts. The polar regions are marked by white areas which increase and diminish with the seasons on Mars, and it is very natural to call these snow caps, from the likeness of their behavior to that of the polar areas of snow and ice upon the earth. The day of Mars is only about 40 minutes longer than ours; the year there is 687 of our days, or 669 of the Martian days. The axis of the planet is tilted out of the perpendicular to the plane of its orbit by 23 degrees 56 minutes, only half a degree more than the tilt of the earth's axis, so that the seasons on Mars will be almost the exact counterpart of our own, except that the length is nearly double ours.

The difficulties in the way of saying at once that Mars is habitable by beings like ourselves are three: the lack of heat from the sun; the lack of atmosphere; and the lack of large bodies of water. Being 1.4 times as far from the sun, Mars receives only half the heat that the earth does, and this fact would argue that in the absence of a dense blanket of water-vapor to retain the heat, the temperature must be extremely low, too low in fact for ice to melt at all. The change of the polar caps contradicts this, and those who argue for low temperature are forced to suggest some other substance than snow to account for the caps.

* Read before the Astronomical Society of the Pacific. Reprinted from *Pub. Ast. Soc. of the Pacific.*

Carbon dioxide has been suggested by some as a substance whose crystals are as white as those of snow, and whose temperature of crystallization is much lower than that of water. But Lowell points out that at pressures of anything like that of our atmosphere or less, carbon dioxide passes at once from the solid to the gaseous state. Water lingers in the intermediate state of a liquid. The Martian cap as it melts is surrounded by a deep blue band, which accompanies it in its retreat, shrinking to keep pace with the diminution of the cap. This is what we should expect if it were water. And if we are to bring in an extra amount of carbon dioxide, a far less increase over the amount found in the earth's atmosphere would so add to the heat retaining power of Mars's atmosphere as to account for the apparently high temperature indicated by the observed seasonal changes.

Of the rarity of the atmosphere there is no question. The mass of Mars is so much smaller than that of the earth that the force of gravity at the surface of the planet is too weak to retain an atmosphere of anything like the density of our own. Even the most ardent advocates of the possibility of life on Mars admit that if one of us were to be suddenly transported to that planet, he would probably die in a few minutes because of the rarity of the atmosphere. But it is claimed that beings like ourselves might gradually become accustomed to an atmosphere much rarer than ours, and this is probably true.

That water is comparatively scarce there, is also unquestioned. The spectroscopic observations of Mars at Flagstaff indicate very little, if any, absorption by water-vapor, and those by Campbell at the summit of Mount Whitney show no trace of any at all. In fact, if Lowell be right, it is this very scarcity of water which has brought about the evidence which comes nearest to proving that there are actually living, intelligent beings on Mars. Crossing the reddish-orange regions, which are considered deserts, in all directions is a net-work of narrow dusky lines, which their discoverer, Schiaparelli, called canals (channels). They are so narrow and difficult to see that it is impossible to assign a color to them, but as they connect always with the bluish-green areas or with each other, it is probable that their color is the same as that of the large dark areas, bluish green, and is due to the same cause. They are extremely difficult to see, and many astronomers have not been able to see them at all. Others glimpse them as broader and hazier than they are drawn by Schiaparelli and Lowell. As a result there has been much doubt as to the real character of these markings. Lowell does not hesitate to explain them as lines of vegetation along artificial watercourses; not the canals themselves, but the irrigated regions on either side of the canals. From his studies at Flagstaff, Arizona, at all the oppositions of the planet since 1894, Lowell finds that the "canals" vary in visibility with the Martian season in such a way as to indicate progressive irrigation, as the water flows from the melting polar caps toward and even beyond the equator. Certain of the "canals" run north and south through the dark areas as well as the light ones, into the regions covered in winter by the polar caps. As the cap melts in spring there first appears a blue band at its edge. After a time the canals nearest this band become visible, then later those nearer the equator, the interval between the melting of the cap and the appearance of the canals being sufficient to allow for the time required, not only for the transference of water, but also for the springing up of vegetation, after the water has reached the irrigated region. The "canals" near the equator on either side have two periods of visibility each year, corresponding to the time when the water would reach them from the two polar caps at opposite seasons of the year. The "canals" as a rule are very straight, running on arcs of great circles from point to point on the globe of Mars. Often several of them meet at a common point, and in many cases at the intersection of two or more of them there appears a round dark spot, to which Lowell gives the name "oasis." The apparent straightness of the "canals" has made astronomers skeptical of their reality, since on the earth watercourses, whether real or artificial, are never straight. They invariably wind about, following the contour of a level or descending line. Either Mars has a very flat surface or the Martians are very wonderful engineers. Perhaps both statements are true. There is no evidence of mountains on the planet, for the terminator never has the jagged appearance which the mountains produce on the sunrise and sunset lines of the moon. Clouds are very rarely conspicuous. I have sometimes seen misty patches over the dark areas, as if there were very thin clouds or fog there, but never enough to entirely obscure the surface of the planet beneath them.

On the whole we must conclude that life on Mars would not be very satisfactory for beings like ourselves. That there may be life there, I would not like to deny. There may be intelligent beings, of a higher order even than ourselves, but of this there is no adequate proof. Lowell in the "Conclusion" of his book "Mars and Its Canals," says "that Mars is inhabited by beings of some sort or other we may consider as certain as it is uncertain what those beings may be." With the last part of the statement we can certainly agree.

The satellites of Mars are so small—not more than twenty or thirty miles in diameter—that they must ages ago have lost all their heat and absorbed their air and water, so they are not the places for life.

Next in order, outward from the sun, we come to the giant planet Jupiter, with his retinue of four large satellites and four small ones. The diameter of Jupiter is 86,000 miles, eleven times that of the earth, but his rotation is so swift that the Jovian day is less than ten of our hours. His average density is only one-fourth that of the earth, i. e., a little greater than that of water. The surface is diversified by belts of red and purple and white running parallel to the equator. These do not suggest the appearance of land and water, but rather of cloud-zones, between which we see perhaps portions of the real surface. The best evidence we can get goes to show that Jupiter has not yet cooled off enough to have a solid surface, but that it is still intensely hot and subject to continual change. He is a sort of semi-sun, giving light and heat to his satellites to make up in part for the diminution of light and heat of the sun at their great distance.

Interesting as the astronomical phenomena as seen from Jupiter would be, with the eight moons circling about him, producing total lunar and solar eclipses every day, we can hardly say that the giant planet is fitted for a place of abode. It is possible that on the satellites the conditions may be more like those on Mars and the earth, but we can tell very little about them. The little we do know points to similarity to our own moon, which we have found to be uninhabitable.

Saturn, the king of the planets, comes next in order, with his golden rings and numerous satellites. Surely this would be a glorious place to live, with the ten moons of as many different sizes and the great arch of meteor rings spanning the heavens. But we find that Saturn is in much the same condition as Jupiter, not yet cooled off. The low density of the planet—less than that of water—and the brightness of its surface—greater than that which could be produced by the reflected light of the sun—indicate a high temperature. Of the conditions of the satellites we know almost nothing. Titan, the largest, approaches Mars in size, and might, so far as size is concerned, be an inhabited world.

The two outer planets, Uranus and Neptune, are too far from the earth to allow us to learn much of their surfaces. Uranus has belts like Jupiter. Neptune has no perceptible markings on his surface. Both are denser than Jupiter and Saturn and of darker color. There is one argument which seems to be pretty conclusive against the habitability of these planets and that is the diminution of the sun's light and heat at such great distances. As seen from Neptune, the sun would have only one-thirtieth of its present apparent diameter and would give only one nine-hundredth as much light and heat. This would hardly be deemed sufficient to maintain life like ours.

We have omitted the asteroids, of which there are now nearly seven hundred known, in our discussion of the condition of the planets. As the largest of these is not more than four hundred or five hundred miles in diameter, it is not probable that any of them are warm enough, or possess atmosphere enough, to sustain life.

In the whole solar system, then, we find but one planet, Mars, on which the physical conditions seem to be suited to life like our own, and even there our constitutions would have to be considerably modified. Some of the satellites of Jupiter and Saturn may also, perhaps, be habitable, but of the condition of these we have almost no positive knowledge.

But how about the stars? Among the thousands, millions, and hundreds of millions of glittering orbs which the great telescopes reveal, are there no inhabited worlds? We can say of each one of these, which is visible to the eye or which the telescope reveals, that it is a sun, an intensely hot, glowing body, shining by its own light and therefore not an inhabitable world. How many satellites or planets there are, circling invisible around the stars, we can only infer by analogy, and we can only infer, again by analogy, that among the myriads of these invisible satellites there may be millions of worlds like our own.

A Vanished Continent

To the west of Africa, the bottom of the Atlantic sinks as low as 10,000 to 12,000 feet and upon this bottom a series of islands rear themselves, these being the Azores, the small Selvage islands, the Canaries and the Cape Verd islands. This group of islands has a special interest, as they are often considered as the remains of the lost continent known as Atlantide. A German sicentist, M. C. Gagel, gives a very good resume of what is known of the geology of these islands, and his work will be valuable as a basis of future conclusions. All the present islands are of volcanic origin, and the craters or elevated points occupy the attention of geologists on account of their great interest, among others the peak of Teneriffe. But under the lava there exists a substratum of older formations, and these give evidence of the soil of a continent, this being the famous Atlantide, of which the present islands are the remains. This under layer is recognized in three of the Canaries and in three of the Cape Verd islands, and is formed of ancient volcanic, sedimentary and other rock. A chalk layer is also found in the Canaries, owing to M. Pitard's discovery. As to plants and animals, the same conclusion is drawn. Many European types of plants are found, corresponding to the flora of the Pliocene epoch of the Mediterranean region. As to the fauna, such as insects, mollusks, land and soft water worms, these also show analogies with the continent. For these and other reasons, the conclusion is reached that these different islands are the remains of a continent lying between Europe and America which subsided at a relatively recent period. There are great differences of level between the sea bottom and the tops of the volcanic peaks, and the transition is extremely abrupt, so that it may be considered as due to recent changes. Fogo, the highest of the ten Cape Verd islands, has an elevation of 5,940 feet, and the sea bottom between the islands goes down as low as 11,700 feet, so that in a distance of less than 40 miles the difference of level is 17,640 feet. The nine Azores lie between one-fourth and one-third of the way to America, and here are summits of over 9,000 feet which lie near deep sea bottoms of 11,000 feet. These islands are entirely of volcanic origin, and the eruptions kept up until a recent date. One eruption as late as 1563 gave rise to the giant crater of Lagoa do Fogo. The Canaries form an archipelago of seven islands, separated from Africa by a 60 to 75-mile arm of the sea, having an immense depth. At Teneriffe, the Teyde peak is no less than 12,000 feet high, or 22,000 feet above the sea bottom. Thus the great differences of level are quite evident.

The Burden of the Absent-Minded Passenger.

To forget is human nature, although some individuals are greater offenders than others in this respect. "Few people among the general public," says the *Electric Railway Journal*, "realize that a carefully planned system is put into operation whenever a conductor picks up a lost article in a street car. This system is probably one which common law and honesty compel, but is also one which makes the careless party a direct burden upon the company. It is consistent also with certain traits of the American public that a case not infrequently occurs where the individual unsuccessful in an endeavor to recover a lost article denounces the street car company and threatens suit to cover the loss. One large city company upon which there is an elaborate system of handling lost articles has found upon looking into the matter that the direct cost in wages amount to $6 a day, not to mention the indirect charge, which cannot be calculated. With an average of about 100 lost articles a day this meant that every article left on the cars cost the company 6 cents, or more than was paid for fare by the absent-minded passenger. The article itself sometimes passed through as many as seven hands and engaged the attention of nine different persons. When we consider that only about 45 per cent of the articles are claimed and that a great deal depends upon the honesty of conductors, the question may well be asked whether it is to a company's interest to maintain any but a simple system which will cover the law and will insure the recovery of articles which have been turned in if they are called for. On the other hand, the argument is not infrequently advanced that railroads should go even further and should advertise daily the lost articles in the newspapers. We have never been able to see the utility of such a demand. A man who has left an umbrella, a package or a pair of spectacles on a car usually realizes the fact soon after he has left the car and he does not need the reminder of a paid advertisement. The justice of such a requirement is even more remote. The company is put to considerable expense at best in having the article returned to its lost and found department and in storing it there. Part of this expense may be recouped by the sale of unclaimed articles, but as a rule the articles thus sold are those which are of such little value that the owner does not take the troube to recover them. On the other hand, there should be no objection to a company occasionally publishing statistics to inform the public of what it is doing at considerable expense in the interest of its absent-minded passengers."

The Berrigan Continuous Bucket-Chain Filter Press

For All Branches of Industry

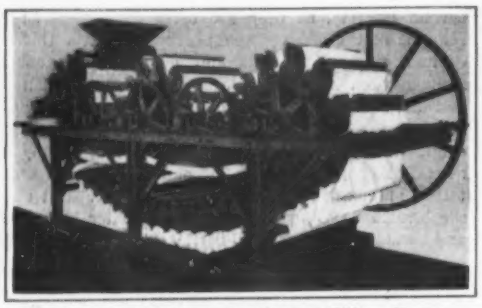


Fig. 1.—The Berrigan Continuous Filter Press.

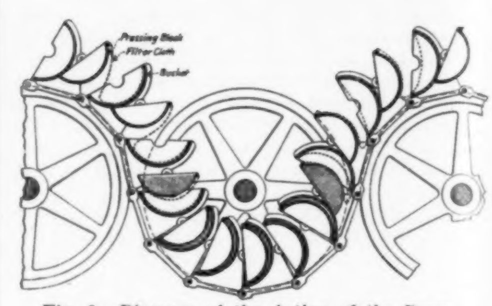


Fig. 2.—Diagram of the Action of the Press.

Filter presses are used in a great variety of industrial practices. In addition to their use in the production of wines and other beverages, and animal or vegetable products such as syrups and oils, they are employed extensively in the mining industry for collecting gold and silver precipitates in cyanide and chlorination plants. They have been used to some extent also in the recovery of grease and fertilizer from sewage sludge. A continuous filter press of most ingenious design and with surprisingly high capacity has recently been built and exhibited at Orange, N. J. Requiring only about one horse-power to drive it, this press can handle material continuously at the rate of 360 bushels per hour. The material is all pressed twice between cloths, the cake being turned automatically between the two pressings.

In the common method of filter-pressing, a number of layers of material are built up, each layer being inclosed in filter cloth, and the whole mass is then subjected to pressure by means of screws or a hydraulic ram. The liquid squeezed out must travel to the edges of the layers in order to escape. In the continuous press to be described, thin layers of material are pressed separately. This method has the double advantage of requiring less pressure, and therefore less power to remove the same amount of liquid, and of permitting the use of a lighter weight of filter cloth, since the cloth is supported at all points by perforated metal plates.

The general appearance of the Berrigan filter press is shown in Fig. 1, which also gives an idea of the principle on which it works. The pressing is done in buckets of semi-circular section, connected in an endless chain. The bucket chain is threaded over and under a series of five pairs of wheels mounted in a horizontal frame. The buckets themselves do not touch the wheels, the bearing being on the projecting ends of the steel rods which serve as pins in the links of the bucket chain. While passing over the top of a wheel the buckets are farther apart, one from another, than they would be if the chain were traveling in a straight line, for the reason that they arrange themselves radially on the wheel, and thus spread apart at their outer edges. Conversely, when passing under a wheel, the buckets are closer together. It should be noted, too, that with the construction shown the buckets are arranged in a semi-circle of smaller diameter when passing under a wheel than when passing over.

Each link of the bucket chain carries both a bucket and a pressing block. The pressing block, or die, fits into the adjacent bucket when passing under a wheel and presses upon the material contained in that bucket.

This action is clearly indicated in Fig. 2. The material to be pressed is poured into the buckets when they are at the top of the first wheel. The pressing blocks are then far enough removed to give free access to the buckets, as shown in Fig. 2. The material is held in the filter cloth linings of the buckets, which form themselves into long narrow bags, as indicated by dotted lines in Fig. 2, and shown photographically in Fig. 1. The buckets are formed of perforated steel plates so that the liquid pressed out through the cloth when the bucket passes down under the wheel can escape through the perforations into the galvanized iron pans below. These pans and the spouts through which the liquor is drawn off from them can be seen in Fig. 1.

The wheel at the right-hand end of the machine in Fig. 1 is the driving wheel and is armed with sprocket teeth which engage the projecting ends of the link pins. The other four wheels are simply idlers whose purpose is to change the direction of the bucket chain. The buckets are filled as they pass over wheel No. 1 at the left-hand end of the machine by means of the hopper and drum shown at the left in Fig. 1. The drum has a longitudinal slit at the bottom through which the material is delivered. Charges of proper size are measured out by means of revolving longitudinal blades inside the drum. The buckets then pass down under wheel No. 2 and the material is compressed, after which they rise upon wheel No. 3. As the buckets pass over this wheel their movement relative to one another causes a shifting motion of the filter cloth which either turns over or crumbles the cakes of nearly dry material left in the bags. As they pass down under wheel No. 4, the cakes in their new position are squeezed again, and finally they are dumped when the bags turn inside out after passing over the driving wheel.

It will be noted in Fig. 2 that every sixth pressing block is shown solid, while the others are in the form of semi-cylindrical shells. The solid blocks are introduced to increase the weight of the bucket chain. The return portion of the chain hanging beneath the wheels includes 30 buckets and has a weight of about three tons, which is utilized to give the requisite tension in the chain. The sag of the return side of the chain is of value in providing against injury to the machine due to the accidental presence of any object, such as a bolt or wrench, in one of the buckets. In such a case the bucket chain cannot be bent, at the point where the obstruction is, to a sufficiently small radius to conform to the rim of the wheel when passing under it. It therefore stands out from the wheel, touching it only at the lowest point in the extreme case. The only result is to take up some of the sag in the return side of the chain, whereas if too little sag were allowed, something would have to give way and the machine might be damaged.

The same action takes place to some extent in the ordinary operation of the machine. With the buckets full of comparatively solid material, the return side of the chain rises several inches. But when the sag is decreased, the tension in the chain increases. Thus the pressure is automatically adjusted to the compressibility of the material in the buckets.

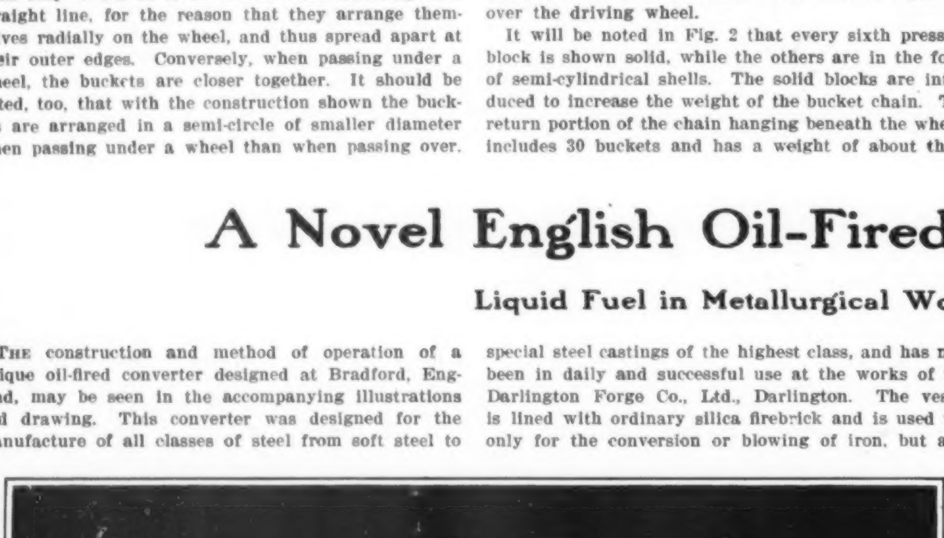
The capacity of the machine is limited only by the speed at which it can be safely and effectively operated. When seen in operation at Orange, N. J., it was run at a speed which gave one complete passage of the chain in 4½ minutes. As there were 54 buckets in the chain, this gives 12 buckets per minute. Each bucket on the machine exhibited was 3 feet long and held about a half bushel of material, so that the machine was running at a capacity of some six bushels per minute, or over 100 barrels per hour. This is many times the capacity of a screw or hydraulic press requiring the same amount of space and horse-power.

It might be thought that this machine, with its tremendously heavy bucket chain, would require an immense amount of power. It is therefore something of a surprise to find that it can be driven by hand, although, of course, at a rather slow speed. As set up for operation, a countershaft not shown in Fig. 1 was so arranged that a spur pinion on one end of the shaft meshed with the large gear shown at the right in the photograph. On the other end of the countershaft was a belt pulley of about the same diameter (say 4½ feet) as the large gear. The machine can be turned by hand by grasping the spokes of this pulley. In operation, the machine was driven by an electric motor of a few horse-power, belted to the pulley on the countershaft.—*Engineering News.*

A Novel English Oil-Fired Converter

Liquid Fuel in Metallurgical Work

The construction and method of operation of a unique oil-fired converter designed at Bradford, England, may be seen in the accompanying illustrations and drawing. This converter was designed for the manufacture of all classes of steel from soft steel to special steel castings of the highest class, and has now been in daily and successful use at the works of the Darlington Forge Co., Ltd., Darlington. The vessel is lined with ordinary silica firebrick and is used not only for the conversion or blowing of iron, but also for melting the actual charge of iron and scrap by means of oil fuel.



Test Samples of Steel Made With the Oil Converter.

The vessel is made oval in section so that a large surface of metal can be exposed to the action of the oil burners. For convenience in working, the vessel, besides being mounted on trunnions working in roller bearings in the usual way, is also mounted on a turntable which can be revolved in the horizontal plane. Three tons of pig iron and scrap can easily be charged by three men in something less than 10 minutes, and when charged, the vessel is moved through an angle of 90 degrees into the necessary position for melting. Cold air is delivered from the blower into the pipes and passes through the heater, the discharge from which is coupled to the converter through a central pipe, the air having been raised to a pressure of about three-quarters pound per square inch and to a temperature of about 800 deg. F. This hot air is used for burning the oil and very perfect combustion is obtained with a resulting economy of fuel. The hot gases from the oil are naturally discharged from the nose of the vessel, and are drawn through the heater by means of the chimney stack at the end.

With a three-ton converter the metal can be melted in about 1½ hours and is then at a high temperature and in condition for blowing, which process only takes

from 15 to 25 minutes, so that a blow during every two hours can easily be made. In blowing, the vessel is merely tipped upward, the necessary hood and chimney for conveying away the fumes being fixed directly above the air-heater. It will, however, be understood that if for any reason it is more convenient to arrange this hood and chimney in any other position the vessel can readily be turned round to such a position. When the vessel is in the position for pouring its contents into the necessary ladle, it is turned through 180 degrees in the horizontal plane from the position in which the blow actually took place.

The blast for blowing is supplied from the same blower that supplies the air for melting, but in this latter case the air pressure varies from 3 to 4½ pounds per square inch. The oil used for melting is the crudest petroleum available, and can be readily stored in any large vessel such as an oil burner. From this storage tank it can be forced by either the blower or an air compressor into a smaller tank which contains a sufficient quantity of oil for from five to six meltings; this service tank is fitted with a coil through which hot air or steam can circulate and the temperature of the oil is raised somewhat so as to decrease its viscosity. This tank is connected to a small independently driven compressor which will maintain a constant pressure of from 30 to 35 pounds per square inch and force the necessary quantity of oil through a flexible pipe to the oil tubes in the tuyere box; these tubes are steel tubes having an internal diameter of about 1/16 inch and point through the center of the tuyeres which are used for blowing. When the melting operation is completed, these oil pipes are withdrawn, the tuyere boxes being so arranged that this can be done in a few seconds.

This system of making steel has the advantage that no cupola plant is required for the melting, as this is effected in the vessel itself; and as liquid fuel is used exclusively for melting, all risks of picking up impurities during this process are avoided, while the loss of iron resulting from cupola melting is saved. The high temperature of the melted charge allows the use of pig iron low in silicon, or the use of higher percentages of scrap, and the metal is in such a state of extreme fluidity that it is possible to make the most difficult and intricate castings. The space occupied is comparatively small, owing to the fact that the vessel can be turned in the horizontal plane so that the arrangements for charging, blowing and pouring can be provided in any convenient positions while a comparatively small amount of power is required.

Oil-Fired Bessemer Converter.

With this oil converter cast steel wheels have been made showing the following analysis: Carbon 17 per cent, manganese 40 per cent, silicon 17 per cent, phosphorus 0.05 per cent, sulphur 0.025 per cent. The tensile test gave 9 tons per square inch; bend test 1 inch square, 180 degrees without breaking, elongation 30 per cent in 2 inches. The ingots produced for high carbon steel wire with this oil converter had the following chemical composition: carbon 70 per cent, manganese 40 per cent, silicon 0.01 per cent, phosphorus 0.017 per cent, sulphur 0.015 per cent. The metal was rolled to 5 gage rod, drawn to rope wire, and stood work well; tensile test 110 tons per square inch.

Turbines in Warships*

The Rational Application of Turbines to the Propulsion of Warships †

By A. C. E. Rateau

DURING the last ten years we have assisted at a considerable development of turbine engines in all navies. The success of these engines has been assured, because they are the only ones which enable us to solve the problem of speed, since the demand for high speed in every class of vessel increases daily. They have, however, other qualities which add considerably to the value of ships fitted with these engines. These qualities are principally endurance, the elimination of hull vibrations, economy of fuel at high speeds, and the fact that the engines are always ready and require no overhauling.

Fig. 1. DESTROYER "VOLTIGEUR"

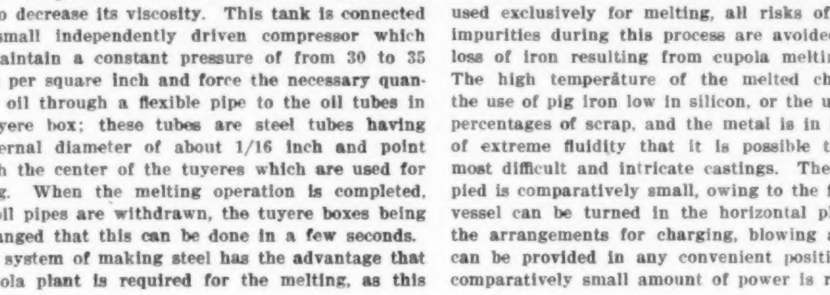
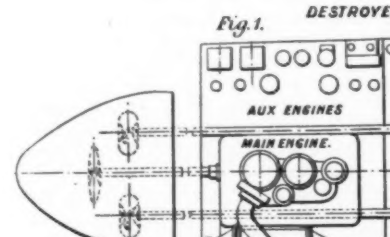


Fig. 3. CURVES SHEWING THE SLIP OF THE PROPELLERS IN RELATION TO SPEED. DESTROYER "VOLTIGEUR"



Great importance must have been attached to these qualities to justify the adoption of these engines, as they have the grave fault of showing a low efficiency at ordinary speeds, which reduces by one-half one of the principal factors of the naval value of ships, viz., the radius of action.

This reduction in radius of action does not have the same importance for all naval Powers. To Great Britain, whose wise policy has given her in all the seas of the world bases of supply not far distant from one another, endurance and constant readiness for action are qualities undoubtedly preferable to all others; consequently, the British Admiralty adopted turbines as soon as they were available, and they can, even now, continue to use them without other inconvenience than the extension of the fuel supply and the improvement of the means of utilizing the same.

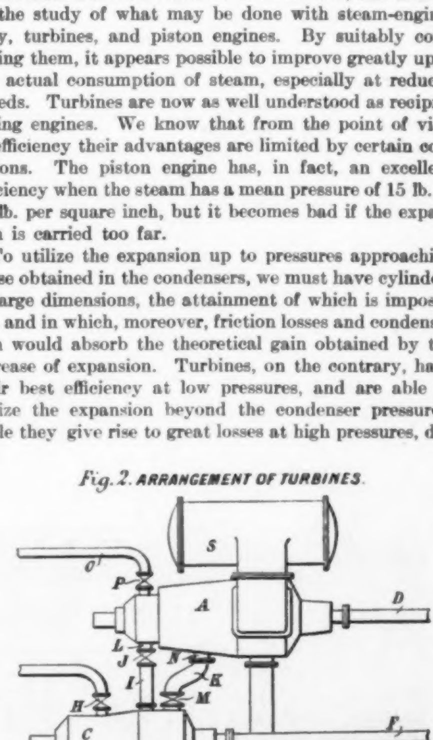
Other nations are not in the same position as regards turbines. They would have to provide in times of war the important convoys of supply, which, however well organized they may be, would form but an uncertain means of assistance, and would reduce the offensive naval war strength of the fleet by the number of the fighting units necessary for their protection. For these nations, therefore, the adoption of turbines has, far more than for Great Britain, meant increased expenditure, and they also have to suffer inconveniences of a strategical nature, which the greatest financial sacrifices can only reduce.

It is not surprising to find that some countries openly regret having followed the example of Great Britain, and that one of the most powerful of these is about to replace turbines by reciprocating engines for her new battleships. One may well hesitate to adopt such a radical course as to forego the advantages of turbines. Makers of turbines are, therefore, endeavoring to make these engines more economical at low speeds. The solution of the problem has been sought by making the propeller shafts revolve independently, so as to keep the turbines at a constant speed of rotation, thus securing a good efficiency; the transmitting gears are in such cases designed with toothed wheels or electric motors. Even admitting that by the introduction of these means of transmission there will not be a considerable loss of efficiency, their employment will always entail a certain complication and weakness, and the machinery so designed will lose two qualities that are most highly appreciated, viz., strength and simplicity.

In the present paper it is proposed to leave out of consideration these methods of transmission, and to keep to the study of what may be done with steam-engines only, turbines, and piston engines. By suitably combining them, it appears possible to improve greatly upon the actual consumption of steam, especially at reduced speeds. Turbines are now as well understood as reciprocating engines. We know that from the point of view of efficiency their advantages are limited by certain conditions. The piston engine has, in fact, an excellent efficiency when the steam has a mean pressure of 15 lb. to 30 lb. per square inch, but it becomes bad if the expansion is carried too far.

To utilize the expansion up to pressures approaching those obtained in the condensers, we must have cylinders of large dimensions, the attainment of which is impossible, and in which, moreover, friction losses and condensation would absorb the theoretical gain obtained by the increase of expansion. Turbines, on the contrary, have their best efficiency at low pressures, and are able to utilize the expansion beyond the condenser pressures; while they give rise to great losses at high pressures, due

Fig. 2. ARRANGEMENT OF TURBINES.



* Engineering.

† Paper read at the Jubilee meeting of the Institution of Naval Architects, July 5th, 1911.

to the friction of the revolving parts in the steam space, also to leakages through the clearances between the moving and stationary parts. Marine turbines are further restricted to low velocities, instead of being able to utilize those which are best for a good efficiency. It is obvious, therefore, that, if we can have an arrangement of combined engines, arranged in series, in which the reciprocating engines utilize the energy of the steam only up to the limit of expansion suitable for a good efficiency, leaving to the turbine the duty of utilizing the expansion down to condenser pressures, we shall then have an engine much superior, whatever be the speed of the ship, to one consisting exclusively of turbines or reciprocating engines.

Ever since 1900 we had foreseen the necessity of a combination of the two kinds of engines. At the meeting of this Institution of 1904 we described the arrangement installed, according to our ideas, by Messrs. Yarrow and Co., on board a small torpedo-boat. In this arrangement the reciprocating engines and the turbines were independent; by working the reciprocating engines only we could obtain very economical results at low speeds. But we must take account of the qualities as well as the faults of each engine; we have managed to gain some advantages, although we cannot eliminate all the faults.

In 1906 we fitted the French destroyer "Voltigeur" with an improved arrangement of engines. The power is distributed on three shafts (center shaft reciprocating engine, with turbines on wing shafts). The engines are so designed that when going at full power the distribution is equal on these shafts. Up to a speed of 20 knots the reciprocating engines exhaust into the turbines, but above this speed the engines become independent. We would therefore have realized a perfect engine up to a speed of 20 knots, if the reciprocating engines and the turbines had been designed solely with the view to obtaining better results by working by stages; but, instead of this, they were designed more particularly with the object of obtaining the maximum efficiency at full power.

However this may be, the "Voltigeur" has undeniably demonstrated the superiority of the system, because below 20 knots the consumptions are slightly above those obtained in destroyers of the same class fitted with reciprocating engines. Above 20 knots, notwithstanding the presence of the reciprocating engines (which under such conditions are not advantageous), the consumptions remain less than those of all other destroyers, even with turbines only. This is due to the superior efficiency obtained with multicellular turbines. See Figs. 1 and 4, showing respectively the arrangement of machinery of the "Voltigeur," and the comparative curves of consumption of the "Voltigeur," "Chasseur" (with reaction turbines), and "Carabinier" (with reciprocating engines). In the author's opinion the best arrangement is the following:—

Combined Engines for Battleships and Cruisers.—The propulsive power is distributed on four shafts, each pair (port and starboard) being worked by an absolutely independent set of engines. In each set a reciprocating engine drives the wing-shaft, and exhausts into a turbine which drives the inner shaft.

The reciprocating engines and the turbines are designed to develop a power equally distributed on the four shafts when running at maximum speed. At cruising speeds the reciprocating engines develop much more power than the turbines. The reciprocating engines should naturally be able to run ahead and astern without engaging the turbines. This design includes an exhaust direct to the condenser; this exhaust opens at the moment when the normal exhaust to the turbines closes by means of two connected valves. These valves are operated automatically when starting, thus avoiding any error or loss of time. It appears unnecessary to introduce astern turbines on the center shafts; but this could be arranged without much difficulty.

With such an arrangement the following advantages are obtained:

1. *Maximum Speed.*—For the same weight of machinery, relatively to the propelling engines, there will be an increase of the maximum power from 15 to 20 per cent, which corresponds to an increase of speed from 5 to 7 per cent of the maximum speed—say 1 to 1.5 knots for battleships intended for 20 knots.

2. *Cruising Speed.*—At this speed the consumption will probably be less than that of ships with reciprocating engines only, and it will not reach one-half of that with turbines. By comparison with the latter the radius of action will be doubled, or, if preferred, it may reduce the fuel supply in the same proportion.

3. *Maneuvering.*—When maneuvering in port it will be found that the arrangement of wing shafts driven by the reciprocating engines is a more favorable one than that of vessels with two or three propellers driven by reciprocating engines only. When maneuvering in squadrons, stations will be as easily kept as by other ships, because regulation of speed can be adjusted by operation of the stop-valve on the reciprocating engines.

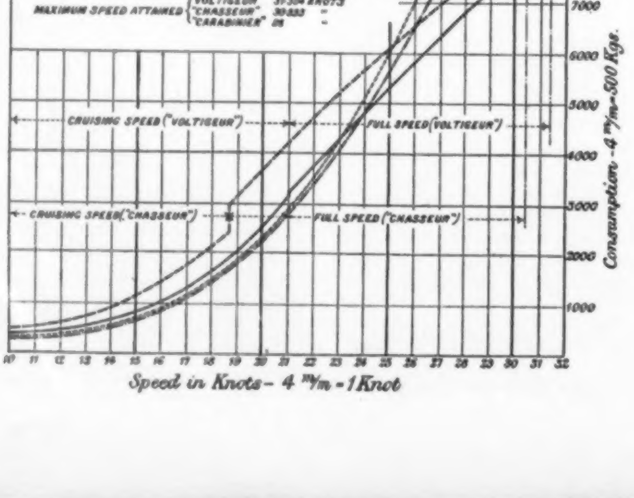
ARRANGEMENT OF TURBINES FOR SCOUTS AND DESTROYERS.

It will be readily understood that, although the distribution of the propelling machinery on four shafts does not present any inconvenience in large ships, it is difficult to achieve in the scout and destroyer classes.

If it is intended to apply the combined system in these small vessels, it will be necessary to adopt an arrangement with three shafts, similar to that of the "Voltigeur," in which, at certain speeds, the reciprocating engine on the center shaft will exhaust into the wing turbines; but in order to retain sufficient maneuvering qualities, it will be necessary to put astern turbines on the wing shafts, and a direct exhaust from the reciprocating engine to the condenser, so as to make this engine independent for maneuvering in harbor.

This arrangement may, perhaps, be thought complicated. To simplify it we may adopt the arrangement recently installed on the White Star Line vessels—two reciprocating engines driving the wing shafts, and both exhausting into the same turbine, placed on the center shaft, and, when maneuvering, direct to the condenser. But the almost universal opinion is that it is wise to give up entirely the use of reciprocating engines for scouts and destroyers. These ships must be capable of developing at full power a considerable speed; they must, therefore, always be ready to pass from an ordinary cruising speed (14 to 16 knots) to very high speeds. On the other hand, the number of men composing the crew is limited through lack of accommodation, and it is necessary without greatly reducing their offensive value, to limit to the strictest minimum the numbers of the engine and boiler-room *personnel*.

The various conditions involve the use of engines and boilers of great flexibility and strength, and requiring the least manual effort; under these circumstances turbines and liquid fuel are essential. The difficulty is to have a good efficiency at ordinary cruising speeds. In order to overcome this, the cruising turbine, which utilizes the expansion of the steam between the receiver pressure and the corresponding pressure at the exhaust into the high-pressure turbine, has been designed for the required speed. But the power developed by this cruising turbine being very small, it is not possible to make it work a propeller shaft by itself. It is, therefore, always placed on a shaft already driven by one of the main turbines. The result has been that the speed of rotation of this cruising turbine, which should be high in order to obtain a good efficiency, has been reduced by the speed of rotation of the main turbine, an obviously low speed, since it is proportional to that of the ship, and also because the cruising turbine does not come in except at moderate speeds of the ship. The efficiency, therefore, is always poor.



Speed in Knots - 4 m/m - 1 Knot

On the new French destroyers there are only two propelling-shafts, each shaft being driven by an independent turbine, as has been the practice since 1898, when the torpedo-boat "No. 243" was used for experiments on the adoption of turbines for small ships.

The old cruising turbines, high-pressure and low-pressure, have been fitted in the same casing, end to end, thus obtaining all the advantage of great simplicity; but it is evident that the "cruising" part of these large turbines cannot give better results than the cruising turbines of engines arranged in separate groups. To avoid these inconveniences, and the use of toothed-wheel gears or electric motors, we have proposed the follow-arrangement, in which the high-pressure turbine maintains constantly at low-vessel speeds a relatively high velocity of rotation, and, in consequence, a higher efficiency.

ARRANGEMENT OF TURBINES.

The ship is propelled by three screws; each shaft is driven by a turbine; only the two-wing turbines being arranged for going astern (see Fig. 2). The center turbine C is fitted with a steam inlet at the forward end G and with a by-pass H. The exhaust of the turbine C is connected with pipes I, I' to the inlets L, L' forward of the turbines A and B, and also by pipes K, K' to some points N, N' farther aft, in the parts of the distributers of these turbines; these have further an inlet of live steam forward through the pipes O, O'. All these pipes are fitted with valves.

When cruising at 15 knots, for example, the valves M, M', P and P' being shut, the turbine C receives steam through G and exhausts into the forward ends of the turbines A and B, which receive no other steam. If the speed has to be increased, we open the by-pass H; the connections of the turbine C with A and B remaining the same.

For higher speeds, steam will be admitted through O or O' into one of the turbines A or B, or both, if necessary; but, to avoid having compression at the exhaust of the turbine C, the exhaust is let out forward at N, N' in the turbines A and B; when the valve M opens, it must at the same time close the valve J. In these conditions the live steam, after having worked in the first wheels of the turbines A and B, mixes with the steam exhausting from C, and the whole works in the last wheels.††

Thanks to this arrangement, the turbine C always works at great speed, but the power developed on the three shafts will not be equally distributed, as at low speeds the center shaft develops relatively more power than at high speeds. If, for example, the power produced at a moderate speed on the shaft F is 44 per cent of the whole, and on each wing-shaft D and E 28 per cent, the proportion at high speed may become 16 per cent on F and 42 per cent on each shaft D and E. The variations of slip of the propellers correspond to these variations of power.

At low speeds, nearly all the power being on the center shaft, the slip of its propeller is great, say from 25 to 30 per cent, while the slip of the wing propellers is small. The conditions will remain similar so long as the live steam is admitted to the center turbine only. When live steam is admitted into the wing turbines the work produced by the center turbine increases very little, the increase of power being almost entirely due to the wing propellers. Their slip increases at the same time as that of the center screw decreases, and the speed of rotation of the latter rises far less quickly than that of the wing screws. The best results have thus been obtained, namely, that at ordinary cruising speed a center turbine does duty as a cruising turbine, having a very high speed of rotation. While cruising, it is not necessary to have both condensers working. The exhaust of the turbines A and B can be advantageously connected by means of a pipe, which is of ample section to maintain an even pressure between the two condensers. In this way, during a long run at low speed, we can economize the motive power necessary to work one of the sets of pumps.

The arrangement which has just been described is not more complicated than that which consists in putting two independent turbines on two shafts only. It has the advantage of being lighter and of entailing less steam consumption at cruising speeds. At high speeds it has the same advantages as the well-known systems of equally distributed power on three shafts, in which the center shaft is driven by a high-pressure turbine, and the wing shafts by low-pressure turbines, which do not receive any other steam than the exhaust of the high-pressure.

The maneuvering qualities of the ship are increased principally for harbor work, where a great advantage is gained by the action of the center propeller on the rudder; in fact, it is only necessary to steam ahead with the center propeller, while the others are maneuvering ahead or astern, and to join the exhaust of the turbine C with any point of the connecting pipe. This extension of maneuvering qualities is all the more important, as

†† This is exactly what happens in the Rateau and turbines, compound type, a great number of which are working in factories.

with the increase in length of destroyers, it becomes more and more difficult for them to enter and moor in a harbor without the aid of tugs.

NECESSITY FOR CAREFUL DESIGN OF PROPELLERS.

In the above description we have purposely left out the question of propellers, which requires particular attention. It will not be inappropriate to conclude this paper by an account of the method of calculation for propellers in those two particular cases. We shall confine ourselves to describing the difficulties.

For the arrangement of turbines only it is not sufficient to make a design suitable for one speed only. If, for example, we are only requiring to have the best efficiency at high speed, where the three shafts have about the same number of revolutions, the same design for the three propellers may be adopted. At low speeds, the center turbine develops a power relatively greater than the others, and its propeller revolves faster than the wing ones; in order, therefore, to obtain a suitable efficiency for cruising speed, the center propeller, generally smaller than the others, must be very carefully designed.

In the case of the combination arrangement with reciprocating engines and turbines, the former develop at low speeds a power relatively high in comparison to those developed by the turbines; this difference decreases in proportion to the increase of speed, and almost disappears at the maximum speed. The slip of the propellers of the reciprocating engines decreases when that of the turbines increases. In designing propellers these peculiarities must be taken into account, and also the difficulty of associating for the same work propellers whose pitches are very different.

The curves in Fig. 3 show the data obtained during the official trials of the "Voltigeur," and they indicate the importance of the variation of slip. The slip of the propeller of the reciprocating engine increases up to a speed of 20 knots; because up to this speed nearly all the power is supplied by this engine, and also because of the influence of the stern wave, which on the measured mile where the trials were made, became defined in the neighborhood of 24 knots.

Above 20 knots, the turbines come into operation, and the slip of the propeller of the reciprocating engine decreases until it reaches a very small value at the maximum speed. Just the contrary happens with the slip of the wing propellers, which is zero at the start, and increases rapidly until it reaches 26 per cent and 28 per cent.

Notwithstanding this relatively high value for the slip of the wing propellers at the maximum speed, the efficiency of the machinery remains good, as is shown by the excellent results obtained at the trials. The "Voltigeur" has really obtained a speed of 31.4 knots instead of 28 knots required by the contract specification.

Let us also point out the remarkable difference in the increase of slip of the wing propellers, although they are similar and symmetrical. This difference certainly arises in great part from the fact that the powers developed by the two wing turbines are not equal; also because, owing to the presence of the center screw, the stream-lines of the water as it reaches the wing-propellers are not symmetrical.

Masticating*

By W. E. Willmott, L.D.S., D.D.S., Toronto

Masticating is generally considered to be merely the grinding of food into small particles, in order to facilitate swallowing and subsequent digestion.

There are other considerations involved, however, the partial digestion of the food in the mouth; the development of the muscles of the face, thus affecting the expression; the development of the teeth and jaw bones; the development and nutrition of the throat and nasal passages. Mastication is accomplished by the action of the teeth of the lower jaw against those of the upper. In the carnivorous or flesh-eating animals, the movement of the lower jaw is limited to up and down motion and the food is crushed between the very uneven surfaces of the upper and lower teeth: while in the herbivorous or grass and grain-eating animals, the movement is almost wholly sideways, grinding the food between the comparatively smooth surfaces of the teeth. As man's diet consists of a large variety of foods, we find a modification of these two forms in a somewhat uneven surface of the teeth and a very free movement of the lower jaw, forward and backward, and from side to side. When food has been taken into the mouth, the tongue moves it back between the posterior teeth, where it is ground into small particles. The movements of the tongue, lips and cheek serve to retain the food in the proper relation to the teeth until it is sufficiently comminuted and mixed with saliva, when it passes backward and is swallowed. This should not be done until the food is thoroughly masticated and insalivated.

The value of thorough mastication is threefold:

(1) *Mechanical.*—The subdividing of the food into fine pieces is of the greatest value to subsequent digestion. The indigestibility of many articles of food is due very largely to the facility with which they may be swallowed without being very finely divided. While meat, eggs, etc., are very readily digested by the fluids of the stomach when in small particles, a lump of either will resist their action for a long time.

(2) *Chemical.*—During mastication the flow of saliva into the mouth is very largely increased by the reflex action of taste and also by the pressure on the salivary glands, of the bones and muscles involved; the flow of the juices of the stomach is also induced. The object of mastication, the trituration and insalivation of the food, is more perfectly accomplished by this action being prolonged and this, "the first process of digestion being thorough, the succeeding ones in stomach and intestines proceed with greater ease, with a saving of energy and vitality."[1]

(3) *Physiological, or the effect on the jaws and surrounding structures.*—The muscles of mastication are very large in relation to the bony structures in connection with them. The exercise of these muscles largely influences the nutrition and development, not only of the muscles themselves, but also of the important structures near them, such as the jaw bones, the salivary glands, the soft palate, the tonsils and the posterior portion of the throat and nasal passages. The development of a bone depends considerably on the amount of exercise given the muscles which are attached to it. Hence in a person accustomed from childhood to thoroughly masticate, we generally find the jaws large and shapely, as well as the teeth regular, the tongue and salivary glands large, and the nasal and posterior nasal passages spacious and the membranes of the mouth healthy. As the teeth are developed within the jaws they necessarily share in the nutrition and proper development. If these bones are properly exercised during the formation of the teeth the tooth germs will grow and develop more perfectly and the teeth will be more resistant to caries or decay, the best preventative of which is efficient mastication.

The ample development of the jaws brought about by prolonged masticating tends to the regularity of the teeth, thus providing a proper "bite" or the proper relation between the upper and the lower teeth.

Why do the vast majority of people not masticate properly? There are several reasons, the most frequent, possibly, being "soft" or "mushy" food. This is most noticeable in the case of children's diet. Where the necessity of mastication is lacking, the instinct for it gradually disappears and the child acquires the habit of bolting its food and very soon comes to reject the harder for the softer foods. It is very important for the proper development of the jaw bones and of the permanent teeth that a child should be given food which cannot be swallowed without thorough mastication.

Another reason is some defect in the masticatory apparatus, and this is very common in those who have not learned to masticate properly in early life. The defects may be irregularities in the arrangement of the teeth whereby they do not come into proper relation, the upper with the lower, thus largely diminishing the area of the grinding surface, or the teeth may be decayed or loose and painful upon pressure, or some may be lost.

What are the evils resulting from improper mastication? Their name is legion. Possibly the most important is the tendency to take too much food. If the food were of a variety necessitating abundant masticating less would be taken, on account of the longer time and the more labor required, but thorough mastication, even of soft foods, "reduces the amount needful, for the more perfectly the food is chewed, the more perfectly is it digested and the more economically is it disposed of in the system." An inevitable result of an excess of food or of food insufficiently chewed is a derangement of the digestive tract resulting in more or less serious indigestion or in some cases even in cancer of the stomach or in appendicitis. Again, in those who do not masticate properly in early life the nasal passages and tonsils fail to properly develop, and in later life also, unless mastication is prolonged these parts are deprived of the stimulating effect of increased flow of blood to the parts, brought about by the action of masticating, and hence are more liable to become diseased both in the child and in the adult. There is no doubt whatever that the lack of efficient mastication predisposes the child and the adult to rhinitis, tonsilitis, adenoids and other affections of the throat and nasal passages. "The prevalence of adenoids among moderns must be the result of the modern system of feeding children and the defective mastication which goes along with it." A sequence of adenoids is "mouth breathing" on account of the posterior nasal passages becoming blocked up. So, also, a sequence of mouth breathing is the predisposition to laryngitis, bronchitis, phthisis, dental caries, irregularity of the teeth, lack of development of the cranial and jaw bones. Another result of lack of abundant mastication is a lack of development of the tongue, salivary glands and jaw bones. The effect on the teeth is very marked. As the circulation in the teeth and surrounding parts is not stimulated, the teeth in infants do not develop properly and after development they are not properly exercised and massaged, while the secretions of the mouth are apt to be scanty and unhealthy. Under these conditions the teeth and surrounding parts are more liable to become diseased. Another result in more mature life is the loosening of the teeth from a disease called pyorrhea alveolaris or Riggs's disease. Realizing the importance of thorough mastication and the evils arising from the lack of such, what should be done? In the first place, the jaws and surrounding parts should be exercised during their development. As soon as an infant shows any disposition to bite hard substances the instinct should be gratified.

At first, a hard rubber ring may be used, but as the time approaches for the teeth to erupt a harder substance, as ivory or coral, may be substituted. It is better, however, to give the child something which is not only hard but nutrient and pleasant to the taste—a chicken bone or a chop bone from which almost all the meat has been removed may be employed. These are not quite as hard as ivory and are, moreover, more attractive on account of the taste. After the teeth have erupted, the child should still have abundant exercise in chewing, for example, hard toast or hard plain biscuits. Of course other foods will be needful as well, but as this article deals only with masticating, mention is made only of the best means to that end.

Once the habit of mastication is acquired the food will not be swallowed before being converted into a fluid. That this habit may be developed and retained through life, it is absolutely imperative that the teeth should be in the proper relation, the upper to the lower; also that they should be free from cavities of decay and firmly fixed in the jaw.

In this connection it should be distinctly understood and implicitly carried out, that every child should make frequent visits to the dentist, and that every one of the first teeth should be filled if decayed, and should be retained in position until the permanent tooth is ready to replace it.

Periodic visits should be made to the dentist by every person and all necessary operations performed in order to preserve the masticatory apparatus in efficient working condition.

In a word, what does efficient mastication accomplish? It divides the food into very small particles; causes a flow of saliva into the mouth, thoroughly mixes the food with saliva, facilitates swallowing, partially digests the starchy foods; excites the flow of digestive fluids in the stomach; develops the muscles of mastication and those of the face, thus affecting beneficially the expression; influences the nutrition and development of the teeth, the jaw bones, salivary glands, soft palate, tonsils and posterior nasal passages; is a preventative, to a large extent, of decay or loosening of the teeth; cures many cases of indigestion. Surely a sufficient benefit to recompense for the small expenditure of time and labor necessary to accomplish it.

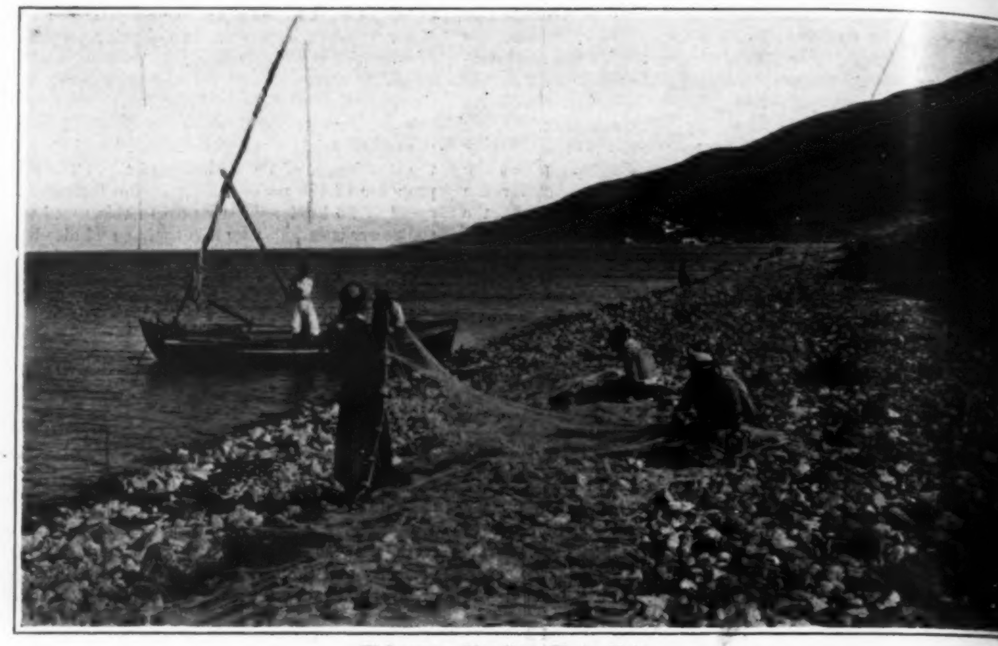
In other words, in what does insufficient mastication result? The food is swallowed before being sufficiently comminuted or sufficiently insalivated; the practice may lead to the habit of eating too much; to serious derangements of the digestive tract; may induce cancer of the stomach or appendicitis; lack of proper development of the teeth, of the muscles of mastication, of the jaw bones and cranial bones, thus adversely affecting the expression; lack of proper development of the throat and nose, predisposing to rhinitis, tonsilitis, adenoids, mouth breathing laryngitis, bronchitis, consumption, dental caries and irregularity of the teeth. Surely a great risk to assume in order to save a little time and trouble.

* Reproduced from *The Public Health Journal.*

[1] H. Campbell, M.D., F.R.C.P. (Lond.), in "The A B—Z of Our Own Nutrition."

Fishermen of t S

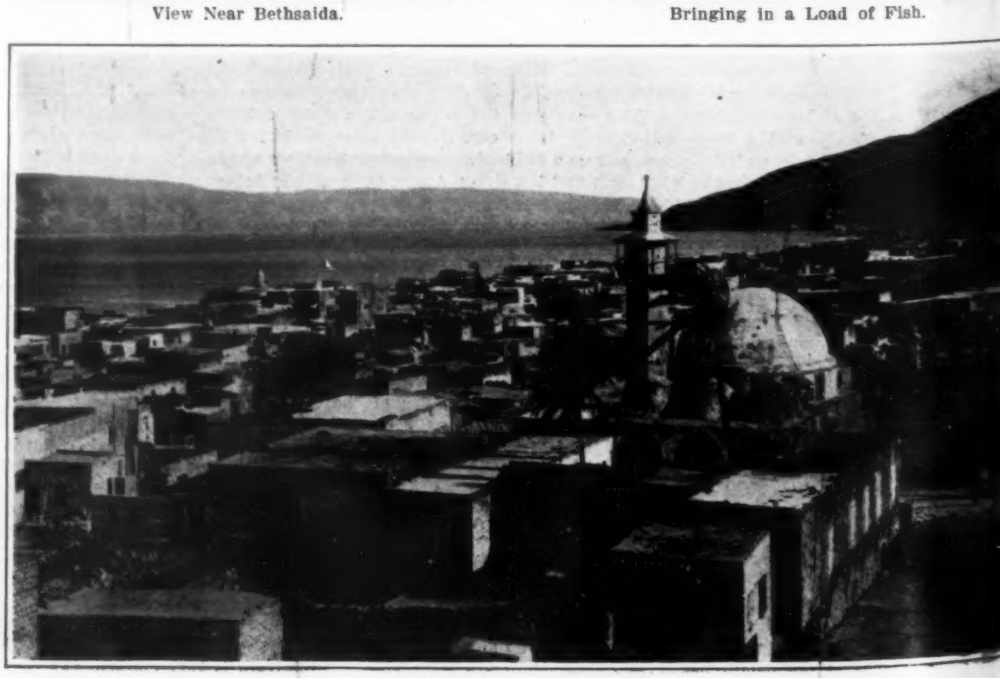
By Harol Shep



Fishermen Mending Their Nets.

View Near Bethsaida.

Bringing in a Load of Fish.



Tiberias on the Sea of Galilee.

WATERFRO AT TIBE

There are few more picturesque sights in the Holy Land than the primitive fishing boats which may be seen upon the waters of the Sea of Galilee. This historic lake in northern Palestine is without question the most sacred sheet of water in the world. One has only to mention that on its shores stood Capernaum, Magdala and Bethsaida to show its connection with the life of Christ.

These historic waters, called the Sea of Chinnereth in the Old Testament, and referred to as the Lake of Gennesaret, the Sea of Galilee and the Sea of Tiberias in the New Testament, are now easily reached by rail from Haifa. Passengers leave the train at Semakh, at the southern extremity of the broad lake, whence ferry-boats run to Tiberias, some four miles distant. This is to-day the largest and most important town upon these waters, and with its mosque, flat-roofed houses, and massive walls and towers, it is truly Oriental in appearance. It has a population of about 5,000, more than two-thirds of this number being Jews.

This is remarkable when it is remembered that when Herod Antipas founded the city, when Christ was a boy in Nazareth, and called it Tiberias, after the Roman Emperor, the Jews refused to enter it. This was because the city was built on the site of tombs, thus rendering it unclean, and also because it contained a racecourse and a palace adorned with figures of animals, which heathen architecture and works of art were regarded by the Jews as an abomination. Antipas accordingly peopled it with a motley populace of foreigners and slaves. Notwithstanding this early Jewish prejudice, it became, after the destruction of Jerusalem, a city of Jewish learning. Talmudical studies are still ardently pursued here, and to-day Tiberias is one of the four sacred cities of the Jews.

Unfortunately Tiberias, lying in a hollow, is extremely hot, especially in summer. We found it quite warm enough in spring. Everyone makes his way to the Greek convent, from which a magnificent view of the lake may be had. Pear-shaped in design, it has a length of thirteen miles, and its greatest breadth, which is from Magdala across to Geresa on the east, is six miles. Its greatest depth is about 150 feet, while its surface is no less than 680 feet below that of the Mediterranean. The Jordan enters as a muddy current at the north end, and emerges at the south quite clear. The waters are sweet and cool, except in the neighborhood of the hot springs, a little to the south of Tiberias, where they are unpleasant to the taste.

The waters abound now, as in New Testament times, with a variety of excellent fish, some of them being a species only found in the tropics. Of particular interest are the *Chromis Simonis*, the male of which carries the eggs and the young about in its mouth, and the *Clarias macracanthus*, the *coracinus* of Josephus and the *barbur* of the Arabs, which emits a sound. Despite this plentiful supply, the fishing fleet of Tiberias cannot number more than twenty craft. They are merely huge rowboats with sail, accommodating a crew of from three to five men. They leave port in the evening, returning with their catches at sunrise. The fish are sold by weight in the market place at Tiberias, and from here they are distributed to nearby towns and villages.

It seems a pity that no effort is made to extend this industry, for in the time of Christ the fishing here gave employment to thousands. Indeed, the appearance of the lake in those days was quite different from what it is to-day. Then it was crowded with boats used for pleasure, merchandise and fishing. So busy was it that Josephus was enabled at one time to gather together 320 boats at Taricaea (now a ruin called Kerak), and so numerous were those who took flight from Vespasian that he had to build a fleet to pursue them. Now its shores are dotted with ruins, the remains of once flourishing cities. For their historic associations these re certainly worth seeing, and in any case a trip around the lake is a delightful experience.

A few miles above Tiberias, on the west side, lies Mejdel, the ancient Magdala, the home of Mary Magdalene, and thought to be the Migdal-el of Joshua.

All that remains of Magdala to-day is a few hovels. From here one sails along the Plain of Gennesaret, picturesque and beautiful, covered in spring with a carpet of flowers, to Capernaum, now called Tell Hum. This plain sinks precipitously to the water and the wind rushes down over it with great force, so that especially in early spring and late autumn storms are very severe.

Sir Charles Wilson tells of a sudden storm he witnessed here. "The morning," he writes, "was delightful; a gentle, easterly breeze, and not a cloud in the sky to give warning of what was coming. Suddenly, about mid-day, there was a sound of distant thunder, and a small cloud, 'no bigger than a man's

of the Sea of Galilee

By Harold Shepstone

Capernaum, at the North End of the Lake.

Selling Fish.

Group on the Shore of the Lake.

Fleet at Tiberias Preparing to Leave for the Fishing Grounds.

ATERFRONT AT TIBERIAS.

band,' was seen rising over the heights of Lubeik, to the west. In a few moments the cloud had spread, and heavy black masses came rolling down the hills, toward the lake, completely obscuring Tiberias and Hattin. At this moment the breeze died away, there were a few moments of perfect calm, during which the sun shone out with intense power, and the surface of the lake was smooth and even as a mirror. Tiberias, Mejdel, and other buildings stood out in sharp relief from the gloom behind, but they were soon lost sight of, as the thunder gust swept past them, and rapidly advancing across the lake lifted the placid water into a bright sheet of foam. In another moment it reached the ruins of Gamala, on the eastern hills, driving my companion and me to take refuge in a cistern, where for nearly an hour we were confined listening to the rattling peals of thunder and torrents of rain. The effect of half the lake in perfect rest, while the other half was in wild confusion was extremely impressive. It would have fared ill with any light craft caught in mid-lake by the storm, and we could not help thinking of that memorable occasion on which the storm is so graphically described as 'coming down' upon the lake."

Nothing remains to-day of the once favored and populous city of Capernaum except a few scattered mud-houses, a hospice belonging to the Franciscans, and a mass of ruins. These last are inclosed by a wall and belong to the monks. Excavations which promise valuable results are now being made. Among the ruins there is an ancient structure built of marble-like white limestone. Large blocks formed the walls. Within are still the bases of the columns, with richly-carved capitals, entablatures, and other fragments lying around. This is thought to be, by some, the ancient synagogue in which Christ often preached.

Not far from Capernaum is Bethsaida, the city of Andrew, Peter, and Philip. The name means "Home of Fish" and to this day fish abound in this portion of the lake and can be seen swimming in the clear, shallow water of the beautiful little bay. Occasionally a native will come down to the water and obtain his supply of fish by throwing in a hand net. The Germans have established a hospice at Bethsaida, but with the exception of this and a few scattered huts and an ancient sea wall, there is nothing of interest here apart from the historical associations.

Sailing past the inlet of the Jordan we commence our return journey down the eastern side of the lake. As we near the Wadi es Semak the hills again approach the lake, and just beyond we reach the inclosed ruins of Kursi, which some scholars have thought to be Gergesa or Gadara, the scene of the deliverance of the one possessed with the legion of devils and the destruction of the swine. There are nearby "steep places" descending to the lake which meet the requirements of the narrative. Proceeding southward we reach Kal'at el Husu, thought to be the ancient Gamala, the hill being described by Josephus as camel-shaped, and deriving its name from the Hebrew and Arabic word meaning camel. It is a position of great natural strategic strength, with precipitous sides except on the east. There are here fairly extensive ancient remains. We farther on pass the village of Samra and soon after reach Samakh at the extreme south end of the lake, and, having circumnavigated the sacred sheet of water, dismiss our boatmen and return to Haifa by rail.

A Resistance Method for Obtaining the Instantaneous Performance of Incandescent Lamps

An interesting series of alternating-current Wheatstone-bridge measurements of incandescent filament resistances at different phases of the current wave is reported on in an article published by Messrs. Edwards and Conner in the *Electrical World*. The bridge with the lamp under test in one of its arms is supplied with alternating currents from electric-light mains, and a rotating-contact device closes the galvanometer circuit once in each current cycle. The measurements show that the tungsten filaments varied from $\pm$ 0.9 to $\pm$ 1.78 per cent above and below the mean working resistance, depending upon the size of the filament. The thinner the filament or the lower the wattage of the lamp the greater the cyclic change in resistance owing to the increased cyclic elevation of temperature. The tantalum lamp was less affected in resistance than the tungsten lamps, while the carbon lamps were still less affected, and affected in the reverse direction. The method should prove very useful in bringing to light the electric behavior of metallic filaments carrying alternating currents. It will be seen that the cyclic change in candle-power amounted to as much as $\pm$ 18 per cent in one instance. The simplicity and convenience of the method described are very striking.

The Power Necessary to Drive an Aeroplane*

Its Numerical Computation

By Sydney V. James

The problems to be met with in the design and development of the aeroplane are numerous and of widespread interest to technical men all over the world at the present time. There are thousands of experimenters working along the lines of aeroplane development and a great many ideas are being tried out in practice. Now that the possibilities of the aeroplane have been fairly well indicated by many successful flights, the interest of the engineering profession is being aroused, and a much more logical development of the numerous problems will be attained, together with the consequent shortening of the time required to reach the practical stage. It is with the hope of creating some interest in the aeroplane from the engineering point of view that the writer will present the following general consideration of the more salient features of the problem of powering an aeroplane.

We shall select, for the sake of simplicity, an aeroplane of the monoplane type such as the Blériot machine and let Fig. 1 represent a plan and side elevation of it as running horizontally in the direction of the arrow. Referring to the figure, a represents the main supporting surface, b the tail surface, c the rudder, d the propeller (which in this machine is a tractor, since it draws the aeroplane along), and e the wheel for running along the ground before the speed necessary to sustain the machine is attained. In order to study the forces acting on the aeroplane, let Fig. 2 represent the side view of the main surface,

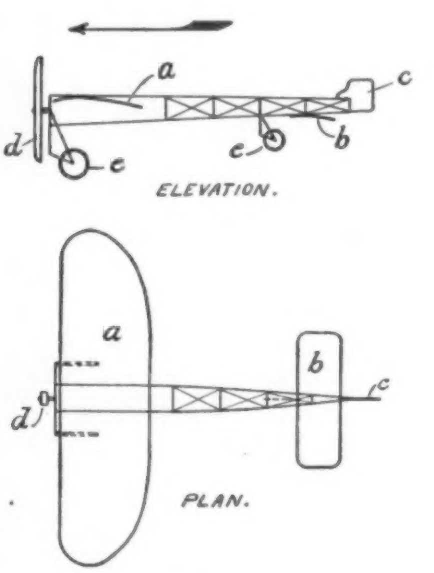


Fig. 1.

with O the center of gravity of the machine. There will be three forces acting when in horizontal flight; ON the resultant reaction of the air pressure on the entire machine; OW the weight, acting, of course, vertically downward; and OP the pulling force exerted by the propeller. For the purpose of this discussion, the above forces are considered as concurrent. This is practically true for most successful aeroplanes.

In flight at a uniform speed, the system of forces is in equilibrium and it is convenient to replace ON by its components perpendicular to and parallel to the line of motion. This is shown in Fig. 3 where OL is the component perpendicular to the line of flight, and OR is one parallel to the line of flight. The forces acting may be considered to be, then, the propeller force OP, the weight OW, the "lift" OL and the resistance to motion OR.

The force OR is opposed to forward motion and must therefore be balanced by OP. The lift OL must be balanced by OW, the weight of the entire outfit, including operator, fuel, etc. As a basis for supplying the proper amount of power, the value of the propelling force must be determined. We know it must be equal OR, hence the value of OR must be determined. The most logical way to do this at the present time is to make as close an estimate as possible of the resistance of each part of the machine, including the horizontal components of the air pressures on its surfaces. This may be done with a fair degree of approximation for any of the well known types, but the value thus obtained must be checked by comparison with values deduced from observations on real machines in actual flight.

Experiments have been made with an aeroplane having its propeller so mounted in the bearings that a calibrated spring would indicate the actual thrust during flight. The results obtained under various conditions with this kind of apparatus give us valuable data for future calculations.

There are other ways of finding the resistance by observation of machines, and the most obvious is to allow the aeroplane to glide with the engine shut off. Under these conditions the path of flight is no longer horizontal, for the machine approaches the earth at a small angle to the horizontal. In Fig. 4 this state of affairs is shown. The path of flight makes the angle θ with the horizontal and the size of this angle is determined by the resistance as compared with the weight of the aeroplane. This is true because the propelling force OR' must be component of the weight in the direction of motion and the machine will adjust itself at such an angle that this force exactly equals the resistance OR. The component of the weight OW' perpendicular to the line of flight balances the lifting

Fig. 2.

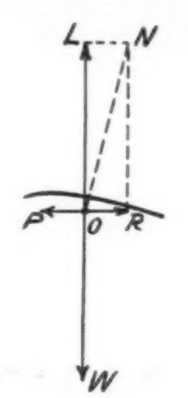


Fig. 3.

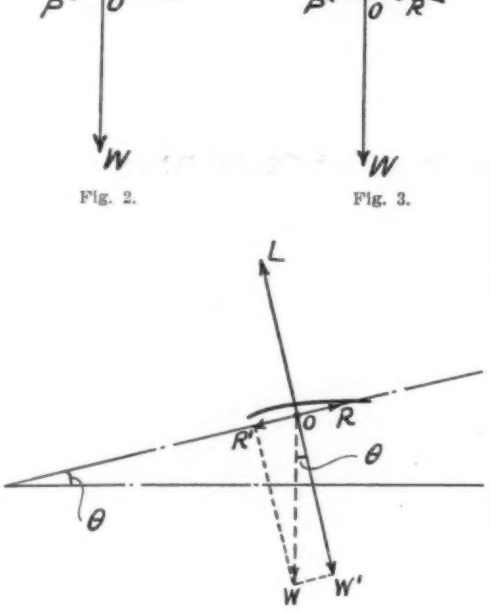


Fig. 4.

force OL and the aeroplane glides at a uniform velocity at an angle θ with the horizontal.

It is clear, after the above condition is realized, that in order to have horizontal flight under power, the propeller must supply a force equal to this resistance. An expression showing the relation between the thrust and the engine power will be necessary, therefore, to find the power. The thrust horse-power may be expressed by the equation:

$$T.H.P. = \frac{TV}{550}$$

where T = thrust or pull of propeller in pounds, V = velocity of flight in feet per second, and 550 converts the foot pounds of work per second of the enumerator into horse-power.

Now the angle WOW' is also equal to θ, and $WW' \div WO$ equals sine θ. But $WW' = R'O$, hence $R'O \div WO$ equals sine θ. Therefore, if we measure the gliding angle and know the total weight of any given machine, the resistance in the line of flight becomes a matter of calculation and is equal to WO sine θ.

If the efficiency of propulsion be represented by e, then the brake horse-power of the engine itself will be

$$B.H.P. = \frac{TV}{550e}$$

By examining the above equation, we see that everything else remaining constant, the B.H.P. varies directly as the thrust required, or in other words, if we have the power required to develop, say, 100 pounds thrust, at the propeller at any given speed of translation through the air, we know that if a 200 pound thrust is required the power must be doubled. Hence, if we work out our data on the basis of 100 pounds thrust, we simply have to multiply the value for the power obtained from these figures by the ratio of the required thrust to 100 pounds.

Substituting in the formula above the value of 100 pounds for T we have

$$B.H.P. = \frac{100V}{550e}$$

hence for any given value of V a curve may be plotted with B.H.P. as abscissa, and efficiency e as ordinate. This has been done for a series of values of V ranging from 20 to 75 miles per hour, in steps of 5 miles, and the diagram shown in Fig. 5 drawn. This covers a range of propeller efficiency from 35 per cent to 80 per cent, thereby including all present practice.

To illustrate the use of the above in figuring out the amount of power, let us take the case of a Wright aeroplane having the following characteristics: Normal speed 35 miles per hour or 51.3 feet per second, gliding angle 8 degrees, total weight about 1,100 pounds. The thrust necessary for horizontal flight would be T = 1,100 sin 8 degrees = 1,100 × 0.139 = 153 pounds. Therefore, assuming 60 per cent efficiency

$$\text{B.H.P.} = \frac{153 \times 51.3}{0.60 \times 550} = 23.75$$

This result can be found by using the chart reading 15.5 B.H.P. at the intersection of the 35-mile line with the 60 per cent efficiency line and multiplying it by

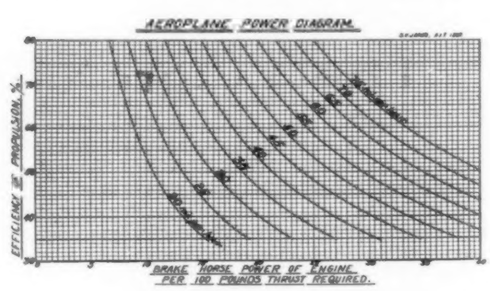


Fig. 5.

the ratio of 153 to 100 or 15.5 × 1.53 = 23.7 B.H.P.

The Wright engine has a full load capacity of 30 to 32 horse-power, thus having a reserve power of about 25 per cent which is called into play when ascending from the ground, or opposing a head wind.

A Blériot XI machine, such as we used in Fig. 1 for example, has the following characteristics. Total weight 770 pounds, normal speed 50 miles per hour, or 73.34 feet per second, gliding slope of about 1 in 7.5 efficiency of propulsion 50 per cent. Hence the thrust required will be $T = \frac{770}{7.5}$ or 102.6 pounds, and the

$$\text{B.H.P.} = \frac{102.6 \times 73.34}{0.50 \times 550} = 27.35$$

This result may also be obtained from the chart by reading 26.7 B.H.P. at 50 per cent efficiency and 50 miles per hour, then multiplying by 102.6 ÷ 100 or 1.026 × 26.7 = 27.4 B.H.P. as above. The Blériot XI is furnished with a gnome motor which develops about 45 actual brake horse-power, hence there is a reserve of about 40 per cent.

The chart is useful in getting a rapid survey of the power problem, showing how much power will be necessary for horizontal flight, as it enables a person to pick out the value for any probable or desired set of conditions as to speed, efficiency and thrust or resistance. It also shows in a graphical way the value of high efficiency and the penalty for low efficiency of propulsion.

* Republished from "The Armour Engineer."

To Bleach Tallow.—100 parts of tallow are melted with 2 parts of water and 1 part of sulphuric acid diluted with 6 parts of water, then one-half part of acid chromate of potash is added. Mix constantly, heat to boiling and allow it to cool; the green-colored fluid is treated for chrome salts and the bleached tallow washed with water.

Removing Emulsified Oil from Water*

The Treatment of Condensed Water for Re-use in the Boiler

By Darrow Sage

Unless one has had personal experience with the difficulties met with in removing emulsified oil from condensed water, he can hardly appreciate the persistency with which the oil sticks to the water. Water which in the form of steam has passed through the cylinders and steam valves of engines and pumps lubricated with cylinder oil, carries with it all the oil that has passed into the cylinders, some of it in the form of drops or small globules of pure oil and the remainder in the form of emulsified or finely divided oil in suspension. The emulsified oil gives the water a milky appearance similar in appearance to water that contains a quantity of air in suspension. In the case of emulsification this milky appearance does not leave the water, as when it is filled with air, and the oil cannot be filtered out by ordinary methods. This finely divided oil must not be confused with the drops of oil above mentioned, which are often seen floating on the surface of water condensed from exhaust steam, as these drops of oil may easily be removed from the water by collecting the mixture in a settling tank from which the water still carrying the emulsified oil can be drawn off at the bottom.

The removal of the emulsified oil to render the water suitable for re-use in the boilers is the real problem. At present there are three well known methods of removing this emulsion, namely:

(a) Filtration through certain kinds of natural sand or crushed stone.

(b) Electrical treatment.

(c) Chemical treatment.

Each of these methods has its particular field, depending upon local conditions and plant equipment. Only the chemical method will be described here.

The commercial name of the chemical used in this process is ferric alum (ferric ammonium sulphate). This ferric alum comes in the form of lumps or crystals having a peculiar bluish tinge which turns to a brownish-yellow color after the exposure to the air. It is easily soluble in water and this property is used to introduce the proper quantity into the water to be purified. From experience it has been learned that about 4 pounds of ferric alum will successfully clarify 10,000 cubic feet of emulsified oil and water, and if this water is recovered at the rate of, say, 4,200 cubic feet per hour, the ferric alum should be added uniformly at a proportional rate. Not only must the rate of flow of the water and ferric alum be uniform, but care must be taken to see that the chemical is thoroughly mixed with the water to be treated.

A convenient way of doing this is to dissolve the necessary amount of ferric alum to last about 24 hours in a barrel of water and permit his solution to flow or drip into the tank in which the return water is caught before it is pumped to the filter, as will be explained later. In making the ferric-alum solution, care must be taken not to produce too strong a mixture, as a saturated solution of this chemical in water is very corrosive. It should never be mixed in greater proportions than 2 pounds to the barrel of water of about 50 gallons and where conditions will permit, less than this. As soon as the ferric-alum solution and the water under treatment have been thoroughly mixed, a pronounced change can be noticed in the milky appearance of the water. It is caused by the action of the ferric alum, which coagulates the minute particles of oil suspended in the water, and thus produces a change that cannot be easily described but can be quickly detected.

After the action of the chemical has taken place the mixture is ready for filtration.

A filter for this purpose can be made from an ordinary tank partially filled with coarse, clean sand which has sufficient area to permit a flow not exceeding 15 cubic feet per hour per square foot of sand bed. The sand bed should be about 2 or 3 feet thick and the sides of the tank must extend above the top of the bed a sufficient distance to provide a separating space for the floating oil. Into this filter the water treated with the ferric-alum solution should be pumped and properly scattered about the surface of the sand bed so as not to wash holes therein and be allowed to pass out at the bottom of the bed through screens and perforated pipes to keep the sand back. The emulsified oil being properly coagulated, it will be caught by the sand and from the discharge of the filter clear water practically free from oil will be obtained. Where it is possible to arrange the filter so that the overflow can be caught, the drops of oil and coagulated scum can be washed out of the filter by simply shutting the discharge valve from the bottom of the tank and permitting the filter to overflow its sides. The floating oil can in this way be skimmed from the top of the tank at regular intervals, but its use as a lubricant is not advisable. By this method the cleaning of the sand bed can be materially postponed, thus getting the equivalent of a longer life out of the filter. With a filter as above described, cleaning will be necessary about every 30 days when working up to its full capacity, it being assumed that there is no more than a normal quantity of oil in the water which passes through the filter.

The cost of operation of a filter plant of this size is small compared to the value of water saved, as the present price of ferric alum is about 20 cents per pound and the cost of saving 10,000 cubic feet of water would be 80 cents plus the cost of the pumping and whatever slight attendance that is necessary to operate the pump and keep it in good condition.

* Abstract of paper read at the annual meeting of the Institute of Operating Engineers, and published in *Power*.

The Future of the Aeroplane in Army Service

By the Paris Correspondent of the Scientific American

The leading Paris journal *Le Matin*, makes the following observations regarding the future of the aeroplane for army use. The military maneuvers which have just closed are an abundant proof of the value of the aeroplane, even when we consider the question very soberly and without any undue enthusiasm, as the facts speak for themselves. In time of war, the aeroplane will be the most rapid messenger which a general will have at his disposal. In fact, in seven minutes Lieut. Blard carried an order from Villersexel to Vesoul, a distance of 17 miles. Legagneux carried orders from Hericourt to Besancon, about 30 miles, in a very strong wind in 25 minutes. This would have been quite beyond the powers of an automobile, to say nothing of the fact that an automobile could not pass over roads covered with infantry or artillery, or across fields, ravines or woods. And we must remember that the usual front of an army corps during battle extends over five miles; moreover, two or three corps may be lined up together, making a line of fifteen miles. A general may need to send an important order to the end of the line, and here the best means will be the aeroplane.

Scouting is the next great service the flying machine will render, and it will be hard if not impossible for the enemy to conceal his movements. No advance guard can give such complete information as to the positions taken by the enemy, the strength of his forces and the location of the batteries. Another duty that will fall to the lot of the aeroplane is to direct the artillery fire. Obstacles in the way often prevent any kind of accurate fire, but this difficulty will disappear with the use of the aeroplane. Artillery assisted by trained aviators will no longer be hindered by topograhical obstructions, but will hit the mark with high percentage.

The utility of the aeroplane for dropping bombs upon the enemy has been disputed. But it appears certain that during the French army maneuvers the aeroplanes could have dropped shells which would have caused much damage, not only to the army but also to railroads and bridges.

It was also observed that the aeroplane camps could be quickly moved from one place to another, for instance on one occasion Capt. Bellanger received orders to take up his camp and simulate a retreat at night. He dismounted the aeroplanes in less than three-quarters of an hour and stowed them in the large wagons invented by Capt. Duperron, together with all the repair material, and made the retreat along the route to St. Julien at 20 miles from there. At this point he set up his camp and unloaded the aeroplanes, put them together and the next morning the aviator made flights through the region.

This will give an idea of what may be expected of the aeroplanes, but it now remains to organize the forces in the best manner so as to make them as effective as possible, seeing that an army which possesses the best organized aeroplane service will have a great advantage. It is evident that the aeroplane service should cease to be a separate organization apart from the army and headed by a few persons. In France the great unit of combat is the army corps, and each corps just as it has its infantry, cavalry, and artillery, should have its aeroplanes which move with it at all times and in fact form part of the corps. For the twenty present army corps there should be as many aeroplane corps and each should be under the exclusive command of the general of the corps. In each case several classes of aeroplanes are needed, firstly, for carrying messages; secondly, for scouting in each division, and thirdly, to accompany the artillery and guide its fire. An aeroplane for each battery would be excellent. Another point is to provide destructive aeroplanes.

Such aeroplanes should be chosen only from among a few leading types which are well known for their good performance. Another point is to establish military aviation schools which are distinct from the aeroplane centers of the army, either a single large institution as Col. Hirschauer proposes, or several as recommended by Col. Estienne. After passing through the aeroplane school the pilot receives his diploma, and not until then is he placed under the army chief. These various points show that the matter of army aeroplanes is already well advanced in France. The progress which has been made since last year's maneuvers is very evident. Last year there were but very few aviators, and they acted more or less as amateurs upon their own initiative. This year the army had over twenty aeroplanes, and they carried out orders very strictly, even in very bad weather, and showed what could be done when aeroplane service is organized on a large scale.

Armored Macadam

The French engineer, M. Guiet, has for some two years past been making experiments with a new road material, with results which, according to the *Revue Scientifique*, have been eminently satisfactory. The material is prepared in rectangular plates of varying sizes and is built up of three superposed layers. The lowermost layer is made of cement concrete, the middle layer, which receives flat and circular iron reinforcing pieces, consists of cement alone, and the third, upper layer is formed of broken stone pressed into the cement layer. A pavement of this kind is not only highly resistant against wear by heavy and rapid traffic but also offers a very smooth surface, thus giving the vehicles a smoother motion than can be attained with stone pavement. For this reason the inventor proposes that in cases where the new material would be too expensive, there should be at least a track of the material laid, to accommodate the wheels of the vehicles. A plate made of the new material and measuring 19 inches in breadth and 28 inches in length will support a uniformly distributed load of 30 tons, without breaking, and a load concentrated at one point, up to eight tons.

A plastic mass which is easily worked and molded, and also after molding, remains soft and plastic, but is not moist and can readily be colored, is plastilina. According to experiments there was obtained, by melting together wax, sulphur, and olive oil and kneading up the materials with zinc-white and finally pulverized, rich clay, a moldable, form-retaining and dry mass. This can readily be colored by the admixture of any desired fine mineral colors. The mass carried a fine wax polish. Where a more marked polish is desired it can be obtained by subsequent coating with celluloid varnish, shellac or ordinary clear spirit varnish. The exact mixing proportions of the mass described must be tested out. The approximate quantities are: Wax, about 50 parts; zinc-white, about 20 parts; sulphur, oil and clay, each about 10 parts. If the mass gets too hard, a little more oil and less sulphur and clay may be used. A similar product is obtained by mixing finely pulverized clay with glycerine in place of water.—*Techn. Rundschau.*

The Doutre Stabilizer

A Promising Design for Automatic Aeroplane Control

The ideal toward which we are aiming in the design of aeroplanes, is a machine which shall automatically adapt itself to the various changes in wind pressure and velocity to which it is subjected in the course of normal flight, thus not only rendering the machine independent of the pilot, but replacing his fallible human judgment by mechanical action devoid of psychological weaknesses. An apparatus which is designed to fulfill at least in part the function indicated is due to M. Doutre, and was recently made the subject of a brief note in the Scientific American. A somewhat more detailed account of the apparatus is here given.

The apparatus comprises two elements each fulfilling a distinct function. The first of these is, properly speaking, an anemometer, whose purpose is to detect changes in the wind pressure; the second element constitutes an accelerometer; its function is to detect and respond to changes in the velocity of the aeroplane. These two elements are so arranged as to act either separately or jointly, according to exigencies, upon the mechanism controlling the elevating rudder at the front of the aeroplane. The anemometer, which is shown in diagrammatical representation in Fig. 3, and in greater detail in Fig. 2, comprises a plate *P*, mounted upon four rods *t*, connected with two tubes *A* which slide smoothly in an aluminium body *S*. Springs *R'* oppose the tendency of the air to force back the plate *P* when the same is moving in the direction from right to left in the diagram. The strength of the springs is so adjusted that when the relative wind is equal to or greater than that required to sustain the aeroplane, the springs *R'* are compressed to their limit and the tubes *A* thrust back against a shoulder upon the aluminium casing. If the pressure of the wind falls below this value the springs *R'* enter into action, thrusting forward the tubes and with them the rods *E* concentric therewith. These latter rods are rigidly connected with the sliding piston rod *T* of an auxiliary motor, the cylinder *C* of which receives through the chamber *D* compressed air acting upon the piston *B*. There is no need to enter into a detailed description of the auxiliary motor, the principle of which is well known; air is admitted into the compartments *H* and *I*, according as the displacement of the piston rod *T* opens or closes the admission ports shown in dotted lines. The surplus air escapes through openings at the end of the rod *T* or the piston *B* as the case may be. Every displacement of *T* is immediately followed, in consequence of the arrangement described, by a displacement in the same direction of the piston *B*. This latter actuates the rudder through a pivoted joint *B'*.

So far the control of the rod *T* by the springs *R'* has been described. But there is a second control, which is effected by the two weights *M*. These are ordinarily kept stationary by the springs *R*. But if the aeroplane makes a sudden plunge, the inertia of the weights causes them to lag behind the motion of the body of the machine. Thus there is a relative motion of the weights *M* in regard to the tubes *A* upon which they slide, a motion which is directed either forward or backward, according as the acceleration of the machine is negative or positive. These movements of the weights are transmitted to the rods *E* and *T* by the pins *B*, and thus react on the auxiliary motor much in the same way as the plate *P*.

A force of 100 grammes weight (3.2 ounces) is sufficient to affect the apparatus, while the auxiliary motor, which receives its air supply from the aeroplane motor, readily gives a thrust of ten to thirty kilogrammes (22 to 66 pounds). This is more than sufficient to operate the rudder.

The anemometer plate and the accelerometer weights both act independently and simultaneously on the elevating rudder. Their effect is either added or opposed, according to the conditions of flight, and the whole is adjusted so as to give the proper steering upon the rudder. Since each variation in the angle of the rudder brings about a variation in the aeroplane speed, the apparatus acts to correct the effect of its own action on the rudder even while this is taking place. It is also to be noted that the apparatus does not wait to act until the aeroplane has taken a false movement, but it acts directly under the shocks which also tend to act upon the aeroplane, thus taking account of the cause itself and not the effect. The correction given to the rudder is thus very quick. The movement of the main rod of the apparatus is transmitted to the rudder in a very simple way by the use of compressed air, the air being furnished by a small compressor driven from the aeroplane motor itself. The compressed air piston device is operated by the main rod, and the piston movement is transmitted in a suitable way to the rudder, passing by the pilot's levers. The pilot can work the rudder himself or he can remove his hands from the levers and allow the automatic device to do the steering, at least for a short time.

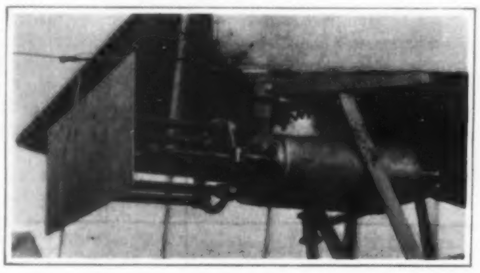


Fig. 1.—Perspective View of the Doutre Stabilizer.

M. Frantz Reichel, a well-known correspondent of the Paris sporting journals, gives an interesting account of a trip which he made as passenger on an aeroplane fitted with the Doutre apparatus, in order to make a personal report about its performance. At the start, while the aeroplane was still rolling on the ground the pilot removed his hands from the levers and left the aeroplane to the automatic apparatus. It soon rose in the air in this way and the pilot took the levers again only after reaching a height of sixty feet. Then they mounted to 1,000 feet and flew steadily along toward Versailles. Here the automatic apparatus worked very well. The small plate kept up a slight beating movement working back and forth over some three inches, as an indicating pointer showed; the rudder followed up this slight movement, so that the flight was very steady. The pilot kept his hands on the levers, but did not work them. The levers moved somewhat under the action of the apparatus. He then raised his hands for periods of four to six seconds, coming back only to take care of the side steering to avoid the rolling movement. At times it was quite evident that no effort was required by the pilot, the automatic device doing all the steering. When the pilot tried to oppose the action of the stabilizer he had to use quite a little force. At one time the apparatus was left for twelve seconds to itself. Then the pilot slowed up the motor several times, and each time the plate and the moving masses gave the right action to the rudder. Coming back to the Issy grounds, the motor was slowed up and the aeroplane descended on a very good slope and the apparatus always corrected the descent so that it took place under the best conditions up to the landing on the ground. The test was thus very conclusive. On another occasion the device was tried by four competent military pilots, Lieut. Col. Bouttieux, Comm. Renaux and others. This performance was closely watched by Gen. Roques, one of the chiefs of the military aeronautic department, and on one occasion, in the presence of a number of aeronautic experts and others interested, he made a trip on the aeroplane himself. When reaching the ground he expressed his satisfaction with the good working of the apparatus and is convinced that it will be of value. Three aeroplanes are to be fitted with it in order to make a more extensive trial.

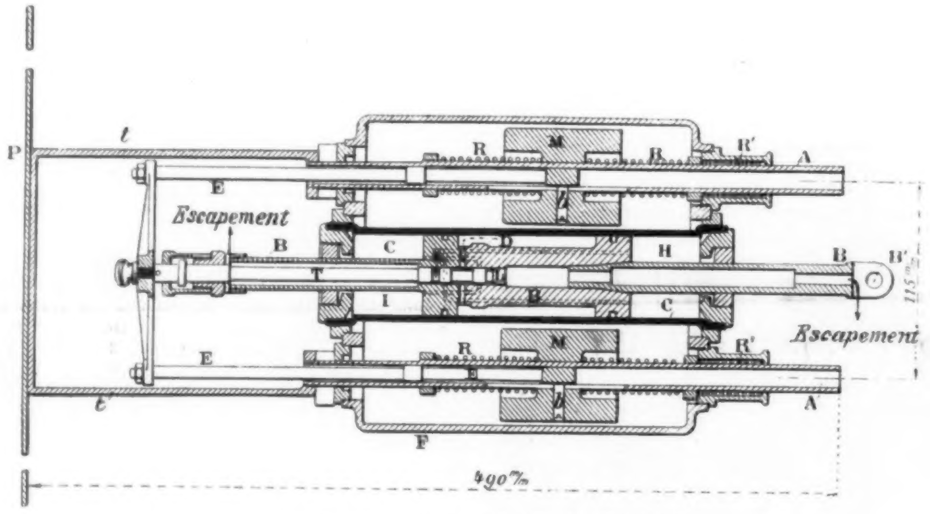


Fig. 2.—Detail View of the Doutre Stabilizer.

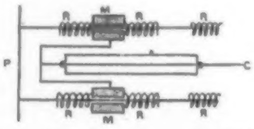


Fig. 3.—*P* = Front Plate. *M* Sliding Weights, Balanced by Springs *R* Which Are Fixed to the Rods at *TT*. Rod is Fixed at the Back at *M*. Plate Works Against the Rear Spring *R'*. *S* = Compressed Air Piston Device for Transmitting *W* (combined Movement of *P* and *M*) to the Rudder by *V*.

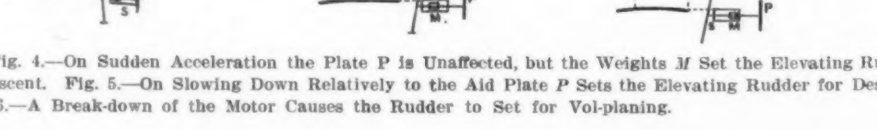


Fig. 4.—On Sudden Acceleration the Plate P is Unaffected, but the Weights *M* Set the Elevating Rudder for Ascent. Fig. 5.—On Slowing Down Relatively to the Aid Plate *P* Sets the Elevating Rudder for Descent. Fig. 6.—A Break-down of the Motor Causes the Rudder to Set for Vol-planing.

Aluminium in the Construction of Brewery Vessels

In a paper published by Messrs. Willcox, Kunz, and Guerst in *Pure Products*, the solvent action of beer on aluminium vessels is discussed. "Aluminium in contact with beer or ale at ordinary room temperatures is weakly attacked. At normal storage temperatures in the brewery the aluminium is also capable of coming into solution, but at so small a rate as to be wholly negligible. For all practical purposes we can say that aluminium is indifferent to beer or ale under laboratory conditions. The action is slightly increased with rising temperature, but even at room temperatures the effects are so slight as to be classed as wholly negligible; although the beer in the bottles containing aluminium were lighter in color and obviously had deposited less sediment, the difference in both respects was so small as to scarcely call for remark. If any importance is to be attached to these facts they could be regarded as pointing to favorable rather than unfavorable influences of the metal on the beer. Experience with the small brewery outfit leads also to the conclusion that aluminium is suitable as a material for the construction of fermenting and storage tanks."

Drying Furnace Blasts With Cacium Chloride*

An Improvement Over the Gayley System

The Gayley process of desiccating the hot blast of a furnace by first cooling the air to a low temperature, and thus precipitating most of its moisture, is not very extensively employed, even in America, where it was first introduced. In Europe it was first employed in 1908, at Cardiff, Wales, and it has since been adopted at the blast furnaces at Bruckhausen, in Westphalia. The desiccation of the blast unquestionably effects a great economy in fuel, but the general adoption of the Gayley process has been prevented by the high cost of installation, which is about $60,000 for a furnace producing 150 tons of pig iron per day. The great furnaces of Westphalia and Lorraine, whose daily production of pig exceeds 1,000 tons, would therefore require very expensive desiccating plants.

Numerous attempts have been made to devise a more practical and less costly method of desiccation based, for example, on the employment of hygroscopic substances. Many such substances are known. The problem is to find one which can conveniently and economically be regenerated, i. e., free from the water which it has absorbed from the blast, so that it can be used repeatedly.

Quite recently the iron works at Differdange in Luxemburg have made trials of a process invented by two French engineers, Daubiné and Roy, and based on the employment of calcium chloride. The results obtained at Differdange were communicated by the inventors to the Iron and Steel Institute at the last meeting of that great association of English metallurgists.

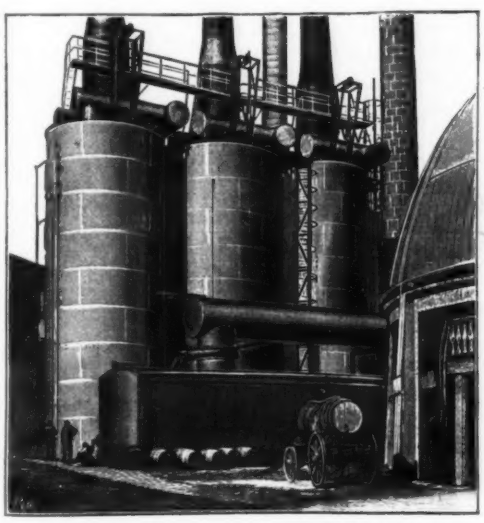


Fig. 1.—Desiccating and Regenerating Towers.

Calcium chloride forms several hydrates, the conditions of equilibrium of which at various temperatures have been studied especially by Rooseboom and Muller Erzbach.

The anhydrous chloride, $CaCl_2$, and the monohydrate, $CaCl_2.H_2O$, absorb water from the air less rapidly than the higher hydrates do, and their regeneration requires a large amount of heat. In the operation of regeneration, therefore, the temperature should not exceed 235 deg. C. (455 deg. F.) at which the monohydrate begins to form.

On the other hand, the mixture of hydrates should not be allowed to absorb from the air sufficient water to form the hydrate $CaCl_2.8H_2O$ which is liquid at the ordinary temperature of the atmosphere, 15 deg. C. (59 deg. F.). At this temperature the lower hydrates are solid and they can consequently be employed in fragments strewn on grates through which the air passes. These hydrates also become liquid at a slightly higher temperature, which may be produced by the heat generated in the process of absorbing water from the air. Hence the hydrates must be kept cool by a circulation of water in pipes, and it is desirable to keep them as cool as possible in order to increase the rapidity of absorption, which is greatest at low temperatures. Precautions must also be taken to prevent liquefaction during the process of regeneration. For example, if sufficient water has been absorbed to produce the hydrate $CaCl_2.4H_2O$, which melts at 40 deg. C. (104 deg. F.), this would be liquefied and lost by an immediate application, in an undiluted state, of the hot furnace gases which are used in the regenerating process. At first, therefore, these gases are greatly diluted and cooled by an admixture of air. As the chloride loses water and becomes less fusible, the proportion of air is gradually diminished and the temperature is correspondingly increased.

The apparatus employed at Differdange is shown in perspective in Fig. 1 and in plan and elevation in Fig. 2. It consists essentially of three high towers, the interior construction of which is indicated in Fig. 3. Each tower is divided into ten stories or compartments, each of which contains a ring-shaped grate which supports a layer of hydrated calcium chloride, about ten inches deep. The air to be dried enters the tower at the bottom and, as the arrows indicate, passes upward through a central conduit, downward through the layers of chloride and the grate, and upward through the annular space surrounding the grates and partitions, until it reaches a collecting chamber at the top of the tower, whence it flows down through a lateral conduit to its outlet, at the level of the fifth story. During this operation each compartment (Fig. 4) is cooled by water flowing in a coil of pipe *s*, buried in the mass of chloride above the grate *g*. The pipe is arranged in the form of a cone, to insure complete evacuation, and all of its joints are inclosed in a water-tight box *b* from which all leakage escapes by the outlet *v*, without coming into contact with the calcium chloride and forming a solution which would corrode the pipe and the grate.

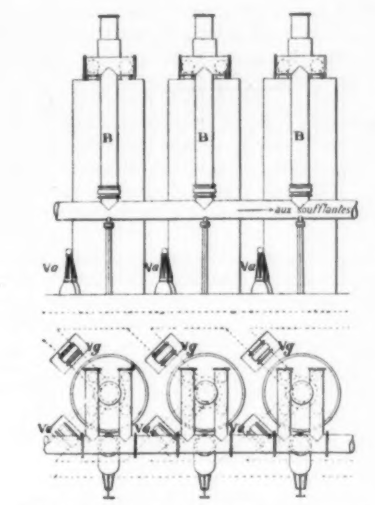


Fig. 2.—Elevation and Plan of Towers.

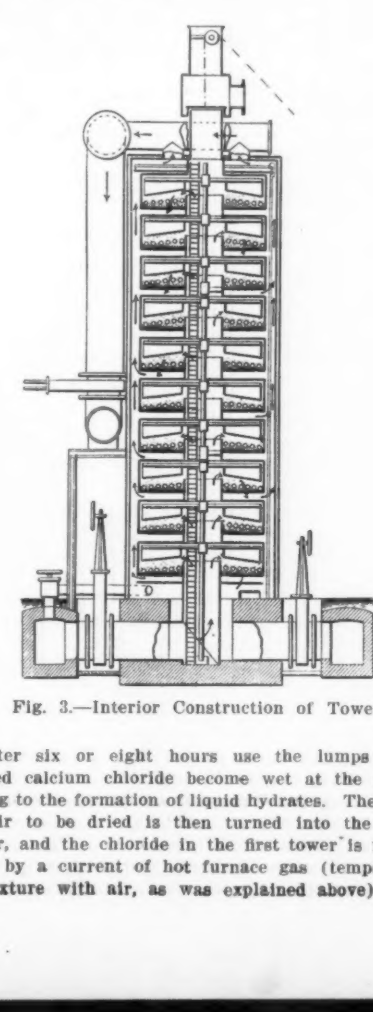


Fig. 3.—Interior Construction of Tower.

After six or eight hours use the lumps of hydrated calcium chloride become wet at the surface, owing to the formation of liquid hydrates. The stream of air to be dried is then turned into the second tower, and the chloride in the first tower is regenerated by a current of hot furnace gas (tempered by admixture with air, as was explained above) which in general follows a course contrary to that taken by the air in the operation of desiccation. The hot gas enters the tower at its base but flows inward from the outer annular space, upward through the grates charged with chloride, and thence to the central conduit, from which it is discharged. Blast furnace gas usually contains so much dust that the chloride would become unfit for use after a few regenerations. The original idea of the inventors was to confine the hot gas to a system of pipes buried in the layers of chloride, and thus to accomplish the regeneration by conduction, and not by direct contact. It was deemed unnecessary, however, to introduce this complication at Differdange, where a sufficient quantity of gas containing very little dust could be obtained.

The regeneration is completed and the chloride restored to its initial condition, in about four hours. The hot gas is then shut off and the hot regenerated chloride is cooled by a current of water flowing through the coils which served to keep the mass cool in the drying operation. The advantage of having three towers is thus explained. While one is being used for desiccation, a second is employed in regenerating the used chloride, and the third is cooling in order to fit it for resuming the work of desiccation. In winter two towers would probably suffice as one could be employed in desiccation for a period long enough to allow the charge of the other to be cooled as well as regenerated, but the third tower is convenient in case of any delay in regeneration or cooling, and it is indispensable in summer, when the increased humidity of the air makes it necessary to shorten the period of desiccation to four hours, in order to prevent liquefaction of the chloride.

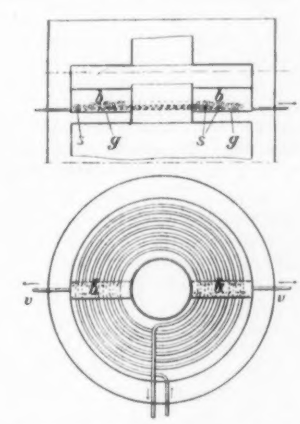


Fig. 4.—Elevation and Plan of a Compartment.

The experiments at Differdange were made with a blast furnace producing 150 tons of pig per day, and requiring a blast of 30,000 cubic meters (about one million cubic feet) per hour. The charge of chloride in each tower was 24 tons, the cross section of the air or gas current about 1,100 square feet, the refrigerating surface of the water pipes about 1,800 square feet. The installation was calculated for the most unfavorable condition presented in summer, when the air may contain 14 grammes of water per cubic meter. In the experiments, which were commenced in winter, the average humidity was 8 grammes and this was reduced to 1 or 1.5 grammes during the entire period of desiccation. In the period of regeneration the temperature of the gas was gradually raised from 30 to 200 deg. C. (86 to 392 deg. F.). In summer the temperature will be raised to 275 deg. C. (527 deg. F.).

In order to reduce the proportion of water vapor in air to 1.5 grammes per cubic meter by the Gayley congelation method, it would be necessary to cool the air to —15 deg. C. (5 deg. F.). The production of so low a temperature by means of refrigerating machines would be very expensive. Air cooled to —5 deg. C. (23 deg. F.), the temperature actually attained in the Gayley process, contains more than 3 grammes of water per cubic meter.

The cost of installing the Differdange apparatus was less than $10,000, or about one-fifth the cost of a Gayley process plant for a furnace producing 150 tons daily. The cost of operation also appears to be much smaller than that of the Gayley process. Only one man is required to watch the operations and move the valves. The calcium chloride method has not been employed long enough to demonstrate fully its advantages and its general applicability. The inventors are studying its application to various branches of metallurgy and industrial chemistry.

* Adapted from articles in *Le Génie Civil* and *La Nature*.

Recent Advances in High Temperature Measurement*

Pyrometers and Thermometric Scales

By J. A. Harker, D.Sc., F.R.S., The National Physical Laboratory, Teddington

Such rapid strides in the science of pyrometry have been made during the past decade that it may be of interest to review recent progress, particularly of the more practical applications. In order adequately to place the subject of recent advances before the non-specialist reader some elementary explanations as to the principles involved are necessary. The most familiar type of temperature measurer is the well-known ordinary thermometer, in which the general property of the expansion of a body by heat is utilized to obtain a scale of temperature. A bulb forming the containing reservoir is blown upon the end of a fine glass capillary tube of uniform cross-section. A liquid such as mercury or alcohol, having a much greater expansion than that of glass, is filled into the bulb, and the changes in volume of the liquid with temperature are indicated by its rise and fall in the capillary tube. If it be desired to compare the indications of the thermoscope thus obtained with those of other observers, it is necessary, in order to convert it into a thermometer, to adopt some definite "scale," preferably as near as possible the same for instruments of all kinds. For this purpose therefore at least two fixed points must be selected. The two universally chosen are the temperature of melting ice and the boiling-point of water under one atmosphere pressure.

On the Fahrenheit scale of temperature in common use in this country, the ice-point is arbitrarily called 32 deg. and the steam-point 212 deg., the interval between them being divided into 180 equal parts called degrees Fahrenheit. Similarly on the Centigrade scale which is almost universally used for scientific and now very largely for technical work, the ice-point is called 0 deg. and the steam-point 100 deg., the Centigrade degree being the one-hundredth part of this interval. Over this small range all substances, both solid and liquid, used in dilatation pyrometers expand fairly uniformly as the temperature rises, and between the same fixed points all give practically the same scale. When, however, observations are made at much higher temperatures it is found that different kinds of glass expand differently, hence two thermometers made of different glasses and both correct at 0 deg. and 100 deg. might differ very considerably at 300 deg. C.

For this reason, therefore, it is desirable to refer all temperature measurements to some scale independent of the properties of the substance used to indicate it. The methods for the practical realization of such an "absolute" scale have been shown by Lord Kelvin, but it is not necessary to enter upon them here. Many years ago it was found that nearly all gases, when sufficiently far from their liquefying points, expand nearly equally for equal rises of temperature. Thus for the mercury in the mercury thermometer we may substitute air, hydrogen or nitrogen, and measure temperature by measuring the changes of either pressure or volume of the gas thus confined. Owing to the larger coefficient of expansion of the gas as compared with the mercury, much greater sensitiveness may be obtained if required, and what is of more importance the expansion of the containing envelope, if its material be suitably chosen, may be made very small in comparison with that of the measuring gas. Hence uncertainties in the knowledge of this expansion become of much less account. A gas-thermometer has also the advantage of being applicable over a very wide range both in the downward and upward direction.

In 1887 the International Committee of Weights and Measures, meeting at Sevres, fixed provisionally the Fundamental International Scale of Temperature, as defined in the following resolution:

"That the International Committee of Weights and Measures adopt as the Normal Thermometric Scale . . . the Centigrade scale of the hydrogen thermometer, having as fixed points the temperature of melting ice (0 deg.) and that of the vapor of distilled water in ebullition (100 deg.) under the normal atmospheric pressure, the hydrogen being taken under the manometric initial pressure of one meter of mercury. . . ."

This international scale was founded on the classic work of Chappuis done at the Sevres laboratory with the large gas thermometer having a bulb of platinum-iridium of over a meter in length and a liter capacity. Chappuis found that the differences between the temperature scales given by hydrogen, air and nitrogen under various initial pressures could be considered as identical for all but the highest class work and that with hydrogen, at all events, the scale thus obtained was probably very close to Lord Kelvin's "absolute" scale. He made elaborate comparisons of the relation subsisting between the readings of a number of specially prepared mercury thermometers made of French hard-glass and the gas-scale. The behavior of this kind of mercury thermometer had been the subject of long study, and the type was a great advance on any previously used. Over the range 0 deg. to 100 deg. the greatest difference between the French hard-glass mercury and the hydrogen scales occurred at 40 deg., at which point the mercury thermometer read higher than the hydrogen by 0.112 deg.

Thermometers calibrated at the Sevres laboratory under the direction of Drs. Benoit and Guillaume, provided with a system of correction tables and capable of being read to an accuracy of about 0.002 deg. C. were sent out with all the national metric standard measures of length and mass, and a number were also issued to science laboratories and kindred institutions. Thus the introduction of the International Scale was rendered possible in practice.

The large Sevres gas-thermometer was not well adapted for work much above 100 deg. C. and investigation showed that at temperatures considerably below 200 deg. C. some action occurred between the bulb and the hydrogen it contained. A second gas-thermometer suitable for much higher temperatures was therefore erected. This was fitted with bulbs of either hard glass or porcelain. With this instrument it was also found impossible to use hydrogen for accurate observations at the higher temperatures, and therefore nitrogen or air was substituted for this gas; at high ranges these give a temperature scale only differing from that of hydrogen by an amount probably within the limits of experimental error. Observations with this gas-thermometer were made up to about 600 deg. C.

Among the most important of the more modern investigations using the gas-thermometer are those of Callendar and of Callendar and Griffiths, who worked with a form of apparatus differing from those of Chappuis in several important points. From the time of Regnault onward the practice seems to have become general to employ the constant-volume method of working. Callendar, however, introduced a form of constant-pressure thermometer, in which several of the most serious sources of difficulty in gas-thermometer measurements were notably diminished. In his instrument the pressure in the working bulb is adjusted by means of a delicate oil-gage to be equal to that of a quantity of gas at 0 deg. C. confined in a second bulb surrounded by melting ice. A system of capillary tubes similar in all respects to those connected with the measuring bulb, and exposed to the same changes of temperature serves to compensate exactly for the uncertain "dead-space" correction. An additional advantage is that the bulb in this method of working is not subjected to any pressure strains internal or external.

Callendar and Griffiths, using this type of thermometer and employing air as their measuring gas, made a determination of the boiling-point of sulphur and obtained the value 444.5 deg. C. under normal pressure, 760 millimeters of mercury.

This point is of special importance in high-temperature measurement, since it has been adopted as the upper fixed temperature of standardization for the platinum resistance thermometer to be described later and on its accuracy the whole scale of the resistance-thermometer depends. This value 444.5 deg. was exactly confirmed by the later investigations of Chappuis and Harker, who found for the same temperature on the constant volume nitrogen scale the value 444.7 deg., the difference between the two determinations being almost exactly that demanded by theory.

Before proceeding to discuss work at higher ranges a few further words regarding the mercury thermometer are necessary. The construction of mercury thermometers for high temperatures has undergone considerable modification of recent years. Investigation had shown that with almost all thermometers exposure to temperatures even as low as 100 deg. C. causes zero changes and with some of the glasses in use these were of relatively large and very uncertain amount. In general the change produced was found to be made up of two parts, the one, a rise of zero, being permanent in its character, the other being a temporary depression followed by gradual recovery after a more or less prolonged period at ordinary temperature. The first of the two effects may be largely overcome by annealing the instrument for some time at a much higher temperature than that at which it is intended to be used, following this by a process of slow cooling to ordinary temperature. The internal strains set up in the glass during manufacture are thus relieved. Formerly it was not uncommon to find an ordinary "chemical" thermometer graduated to 360 deg. C. show a permanent rise of 10 deg. or even 20 deg. after a brief exposure to 300 deg. or 350 deg. Owing to the introduction of better glasses and improved methods of manufacture these large permanent changes are now much rarer and the temporary depressions much smaller than used formerly to be the case. Another important change in the modern method of constructing a mercury thermometer for use above 100 deg. C. is that, instead of exhausting the space above the mercury, for work up to 350 deg. C. this is now almost always filled with nitrogen at approximately atmospheric pressure. The pressure of the gas prevents the splitting up of the mercury column, which often occurs above 250 deg. C., if the thermometer is vacuous. By the use of some of the newer refractory glasses composed of borosilicates, thermometers are now constructed which will stand brief exposure to 550 deg. C. or even 575 deg. C. To raise the boiling-point of the mercury sufficiently, the filling of nitrogen or carbon dioxide gas is introduced under 16 atmospheres pressure. This type of thermometer, graduated usually into intervals of 2 deg. or 5 deg. C., is generally divided from about 180 deg. C. to 550 deg. C. and for checking purposes is provided in addition with either the freezing or boiling-point. The divisions instead of being approximately equal volumes throughout are made gradually shorter at the higher ranges to bring the readings into accord with the gas-scale. The use of these thermometers above about 480 deg. C. is however not to be recommended, as any prolonged exposure (say an hour or two) even to 500 deg. C. only, generally leads to the gradual softening of the bulb, which blows out under the considerable internal pressure.

In the use of high-range thermometers the fact is often lost sight of that if the whole of the mercury up to the reading be not subjected to the same temperature as the bulb very considerable errors may arise. In technical work very many disputes have been caused by lack of attention to this point. The amount by which a correctly divided thermometer would read low under these conditions may be roughly estimated from a knowledge of the number of degrees in the thermometer stem, which are not at bulb temperature, the average temperature of the exposed portion, and the apparent coefficient of expansion of mercury in the particular kind of glass used over the range in question. An approximate value for the latter at moderate temperatures is 0.00016. The determination of the "stem correction" as it is called is, however, at best very uncertain, and if the extent of exposed stem be grect and the temperature high, the correction may reach 30 deg. C. Thus, for example, if the bulb temperature be 300 degrees and the amount of stem exposed be 200 degrees at an average temperature of 50 deg. C., the correction would amount to 9 deg. C. It will thus be seen that if a mercury thermometer be intended to be used only partly immersed, either it should be graduated to read correctly with some definite amount of exposed stem or a correction must be applied.

During the past few months experiments have been commenced with a view to the manufacture in England on a large scale of mercury thermometers in which fused silica is substituted for glass, the difficulties in the way of the construction of capillary tubes of reasonably uniform cross-section having been largely overcome. Owing to the well-known excellent properties of silica-glass at moderate temperatures these thermometers, if produced sufficiently cheaply, should present notable advantages.

Our knowledge of high temperatures has been greatly extended during the past ten years by a number of researches, among which may be mentioned those of Holborn and his associates working at the Reichsanstalt at Charlottenburg, of Day and his coworkers at the Geophysical Laboratory at Washington, also the work of the American Bureau of Standards at Washington and the National Physical Laboratory at Teddington. These and other workers have carried gas-thermometer measurements to much higher temperatures and by perfecting various forms of electric furnace to obtain the necessary uniformity of heating, have succeeded in reaching comparative agreement at temperatures up to 1,000 deg. C., the upper limit of the experiments thus far made being 1,500 deg. C.

Although the gas-thermometer, as representing as nearly as possible the absolute scale, has been accepted by general consent as the ultimate standard of tem-

* Reproduced from *Science Progress*.

perature measurement, to use it successfully even at moderate temperatures is extremely difficult. Much labor has therefore been spent on the evolution of suitable appliances to serve as "working" rather than "primary" standards. Of these the most successful and easily applicable for moderate ranges are the electrical methods of temperature measurement, the first of these being the method of the electrical resistance thermometer. This depends for its application on the fact that the resistance of most conductors made of pure metals changes rapidly with the change of temperature. For the higher temperatures the refractory character, ductility and general properties of platinum first used by Siemens have caused it to be specially selected for this purpose and in most resistance methods this metal is now used.

The platinum thermometer has the great advantage that, provided the wire used for the "bulb" be comparatively pure, standardization at three points only is required to establish a temperature scale serving for measurements up to 1,000 deg. C. If the symbol *pt* be employed to denote any temperature on the Centigrade platinum scale, and R, R_{100} and R_0 are the observed resistances of the thermometer at the temperatures *pt*, 100 degrees and 0 degree respectively,

$$pt = \frac{R - R_0}{R_{100} - R_0} \times 100.$$

To reduce temperatures on the platinum scale to the gas scale the relation between T and pt must be known. Callendar showed that up to 600 deg. C. their difference could be expressed by the equation

$$T - pt = \delta \left[\left(\frac{T}{100} \right)^2 - \frac{T}{100} \right]$$

the value of δ for most pure wires being approximately 1.5. Following his suggestion platinum thermometers are now almost universally standardized by determination of their resistance in ice, steam and sulphur vapor.

Platinum thermometers having a protector tube of glazed porcelain may be employed up to 1,100 deg. or 1,200 deg. C. for intermittent, and to 800 deg. or 900 deg. C. for continuous work without serious changes taking place in the wire, provided the instrument has before use been subjected to a thorough annealing process. Care should also be taken that the protecting sheath be quite gas-tight, to preserve the platinum from the reducing action of furnace gases. Vapors of metals, such as iron, which in an oxidizing atmosphere has an appreciable tension at 1,000 deg. C., rapidly destroy the platinum metals and should be particularly guarded against.

Recent improvements in the apparatus used for resistance measurements, and in particular the introduction for use in resistance coils of metals having practically no temperature coefficient, have rendered possible the design of portable commercial forms of platinum pyrometer outfit and capable of giving high accuracy. One of these forms is made direct reading on the gas-scale, if required; when arranged for use up to a maximum temperature of 1,200 degrees it can be set to one-fourth deg. C. Such pyrometers are eminently suitable for the heat treatment of steel over the range 700 deg. to 900 deg. C., where, in some kinds of commercial practice, a difference of 5 deg. C. in the hardening temperature makes a quite perceptible difference in the nature of the product obtained.

Recently a new form of platinum thermometer has been introduced, in which the wire, instead of being wound on a mica cross, is wrapped upon a tube of clear, fused silica, a second silica tube being shrunk over this for mechanical protection. Thermometers of this type may be constructed so that their lag is very small—a matter of importance in some cases. It has been found, however, that at high temperatures fused silica devitrifies slowly, reverting to its crystalline form of tridymite, and that it is therefore not desirable to submit any pyrometers in which this material is employed to temperatures above about 900 deg. C. except for short periods.

Platinum thermometers have the advantage that they can easily be arranged to give a continuous record, and for purposes where automatic temperature registration is desirable over long periods they are extensively used. For records of the temperature of the hot blast for iron furnaces, and for flue and steam temperatures, they are probably the most suitable instruments to employ. For use in scientific work as in practical standards, they present the great advantage over thermo-couples that the same instrument may be used, if required, for a range of from 0 deg. to 1,100 deg. C. with approximately constant sensitiveness; also that it is easy to design instruments, whose size and shape, resistance and sensitiveness are best adapted to the particular purpose in view.

The second electric method of temperature measurement is founded upon the fact that, in a circuit composed of two different metals, if one of the junctions is heated, a thermo-electric current is produced dependent on the temperature difference set up. The chief advantages of the method over that of the resistance thermometer are that if suitable metals are used it is applicable up to considerably higher temperatures; also that it is possible by its means to measure the temperature practically at a point, instead of the average temperature over the space occupied by the "bulb" of a resistance thermometer, which may be any length up to 4 or 5 inches. The metals generally employed for work at high ranges are those of the platinum group, two of the most useful couples being formed of a wire of pure platinum on one side against an alloy of platinum with 10 per cent of iridium or rhodium. The electromotive force given by these couples is rougly fifteen microvolts[1] per degree C. for the iridium and ten for the rhodium. Wires from 0.3 to 0.6 millimeter diameter are usually employed.

The rhodium couple may be used with success in technical work up to about 1,300 deg. C., if well protected from the action of furnace gases and the iridium couple to about 1,000 deg. C. The glaze of the porcelain outer tubes is, however, rapidly destroyed at temperatures beyond 1,200 deg. C., and most kinds of glaze are viscous at about 1,150 deg. C. Objections have been urged that, owing to the volatility of iridium, its use in a thermo-couple is not advisable. Experience in the use of many kinds of thermo-couples has shown, however, that over the range of temperatures employed for the heat treatment of iron and steel round 800 deg. C., there is little difference in the durability of the two alloys, though the rhodium alloy should always be used, if continuous work above 1,000 deg. C. is intended.

For ordinary purposes the readings of the electromotive force of couples are made by connecting the terminals of the couple directly to some form of galvanometer and in nearly all cases the type of instrument employed is the moving-coil galvanometer in which a small suspended rectangular coil, carrying the whole current, moves in the field of a strong permanent magnet. This type is chosen on account of its freedom from external magnetic disturbance and its constancy of sensitiveness. The readings are taken either by means of a pointer moving over a graduated scale or by the familiar "light-spot" method of the physical laboratory invented by Lord Kelvin. Owing to the fact that the electromotive force given by these couples is comparatively small it was not found practicable till the last few years to make a good portable galvanometer on which the temperature readings could be taken. Now, however, there are on the market several types of commercial instrument which are amply sensitive without the use of the light-spot and are free from zero-drift. It is possible with care with such an instrument of the better class to measure moderate temperatures to about 1 deg. C., if the temperature of the "cold junctions"—that is, the point where the two wires of the couple itself are joined to the copper connecting leads—be known to a sufficient degree of accuracy. Unless the temperature coefficient of the galvanometer employed be sufficiently small and its resistance sufficiently high, resistance changes in the circuit also affect the result, generally in a somewhat uncertain manner; hence for the highest class of work the directly deflected galvanometer is replaced by a suitable potentiometer, in which part or the whole of the electromotive force generated by the couple is balanced. On such an instrument, if correctly designed, it is possible with ease to follow temperature changes to 0.05 deg. C. during the freezing of a pure silver crucible in an electric furnace or to measure the melting-point of platinum on the thermo-electric scale to within 1 deg. C.

One of the most important recent improvements in thermo-electric pyrometry has been due to the fact that two firms have succeeded in producing large homogeneous ingots of platinum and of the 10-per-cent alloys used for thermo-couple wires in a state of high commercial purity, and that thus it is possible to substitute for any couples others giving the same constants. This saves much labor in the recalibration of instruments.

Base metal couples of various kinds have been introduced for work at lower temperatures. Thus for temperatures to 800 deg. C. the alloy of copper and nickel, known as eureka or constantan, may be used against a wire of soft copper or iron. The sensitiveness of the latter combination is roughly 50 microvolts per degree C., increasing slightly with rise of temperature.

During the past decade very great progress has been made in the development of some entirely new methods of temperature measurement, and pyrometers for which considerable accuracy is claimed are now available for the determination of the highest obtainable terrestrial temperatures, such as that of the crater of the electric arc. These depend on measurements of the radiation given out by the hot body, from which its temperature can be estimated. A convention has arisen by which these pyrometers using visible light only are spoken of as "optical" pyrometers, and those in which the whole heat spectrum is concerned as "radiation" pyrometers. Both types have the advantage over the resistance pyrometer and thermo-couple, that no part of the instrument itself is subjected to the destructive action of the high temperature.

The intensity of the radiation emitted by a hot body increases enormously with rise of temperature, the amount of the increase varying with the wave-length. An incandescent body at 2,000 deg. C. emits more than 2,000 times as much red light per unit area as it does at 1,000 deg. C.: hence it would appear that a photometric measurement of the light evolved from any very hot substance should be a sensitive and easy way to measure its temperature. If at a given temperature all substances emitted the same amount of light, this would certainly be the case; but it has been found that, under ordinary conditions, the nature of the radiating body, especially of its surface, greatly affects the amount of radiation sent out. Carbon or iron emit per unit area considerably more light and heat than incandescent platinum or molten copper at the same temperature. The work of Stewart, Kirchoff, Wien and others has shown, however, that if substances of varying emissivity are placed inside a uniformly heated inclosure and looked at through a small aperture in its wall, the amount of radiation sent out under these conditions is independent of the substance and is a function only of the temperature. Such an inclosure is called by Kirchoff a "black body."

The relation between the temperature and radiation from a black body has been accurately studied, and it has been found that the total energy radiated per unit area is proportional to the fourth power of the absolute temperature.* Thus if Q be the quantity of heat radiation, T and T_0 the absolute temperatures of emitter and receiver, and k a constant,

$$Q = k(T^4 - T_0^4).$$

When T_0 is atmospheric temperature and $(T - T_0)$ exceeds say 500 deg. C., T_0^4 becomes practically negligible in comparison to T^4, and T becomes $\sqrt[4]{\frac{Q}{k}}$.

In order to make any radiation or optical pyrometer give correct readings, it is necessary that the substance whose temperature is to be measured should either be one by nature approximately "black," like carbon, or that it should be placed inside an inclosure in which it radiates under "black-body" conditions. In practice the approximation to "blackness" of many furnaces whose temperatures are to be measured is very close. If it is undesirable to have an opening in the furnace, a long tube closed at one end and made of iron, fireclay, or other refractory material may be built into the furnace wall, and readings are then taken by sighting on the bottom of this tube. This arrangement, while giving a good approach to "black-body" radiation, also serves to keep any flames which might be present from exerting disturbing effects on the readings obtained.

One of the most important of the new forms of instrument is the Total Radiation Pyrometer of Féry, which depends for its action on the law just enunciated. This pyrometer is none other than the instrument used by the late Lord Rosse in his researches on lunar radiation, modified to a smaller form adapted for the purposes of temperature measurement. It consists of a reflecting telescope of short focal length, which is sighted upon the hot object. The radiation received is concentrated by a gilt concave mirror upon the junction of a very minute and sensitive thermo-couple placed at the focus. The terminals of the couple are connected to a millivoltmeter, which may be graduated to read directly the temperature of the body on which the telescope is pointed. The usual types of the instrument are graduated from 500 deg. C. upwards and the sensitiveness becomes greater the higher the temperature, differences of about 2 degrees being measurable at the higher ranges. To obtain this sensitiveness, however, the range of any one pattern is usually limited to 700 or 800 degrees from the first graduation. For the millivoltmeter, if desired, a recording arrangement can be substituted by which a continuous trace can be obtained. This may, if required, be at some distance from the furnace.

A simpler form of the Féry instrument is now made, in which for the thermo-couple and registering galvanometer is substituted a very small bimetallic spiral actuating a long aluminium pointer, moving over a scale graduated directly in temperature degrees. Both of these instruments are arranged to give readings independently of their distance from the emitting source, provided the latter is large enough to give in

[1] One microvolt = one-millionth of a volt.

* The "absolute" temperature of a body is its temperature as measured not from that of melting ice, but from "absolute" zero. On the Centigrade Scale this point is − 273° C.; hence absolute temperatures are obtained by addition of 273° to the Centigrade temperature.

the instrument an image of sufficient size to cover the receiving disk. The readings are independent of the personal element introduced by the observer, no question of individual judgment as to equality of brightness or color-matching being involved. On the other hand the disadvantages of the total radiation instrument are that it requires a larger area of uniform temperature upon which to focus than the other types of optical pyrometer, and that no glass, mica or other absorbing screen may be interposed in the path of the rays, unless special arrangement be made to determine for each temperature the considerable absorption thus caused.

Other total radiation pyrometers are those of Thwing and of Foster. Though the details in these are quite different, they are both constructed on the same principle as the electrical type of Féry Absorption Pyrometer. In these instruments and also in that of Wanner only light of one wave-length is used for pyrometric measurements. All three are photometers, in which comparisons are made of the intensity of the red light coming from the hot body, whose temperature is to be measured, with that from a standard lamp of some form or other. A system of lenses forming a telescope of low magnifying-power is used and the measurement consists in adjusting to equality two patches of light, which appear simultaneously in the field. In the Le Chatelier instrument, this adjustment is made by altering the size of an iris diaphragm; in the Féry by sliding past one another two graduated absorbing wedges. In both these instruments a real image of the object whose temperature is to be measured is formed by the telescope; the comparison source is a standard lamp, in which amylic acetate is burnt in a flame of stated dimensions. In the newer forms of the latter instrument three overlapping temperature scales are usually provided, the lowest temperature on the first scale being 800 to 900 deg. C. and the highest measurable about 4,000 deg. C. In the Wanner instrument the comparisons are made by adjusting to equal brightness the two similar halves of a circular disk of light one part of which is illuminated from the object sighted upon, and the other from a small electric lamp attached to the instrument. The brightness of the lamp, which is maintained incandescent from a portable 4-volt accumulator, is previously adjusted to the desired amount by comparison with an amylic acetate standard flame. The Wanner instrument differs from the other two in that it is not an ordinary telescope, but a straight-vision spectrophotometer and that no real image of the object on which it is sighted is formed by the optical system. The chief advantages of these instruments over the total radiation pyrometer are that they can be used on smaller objects; if required readings can be taken through an interposed window, with very little alteration in the results obtained. The Féry absorption type can be employed for the determination of the temperature of the electric arc or even of an incandescent lamp-filament.

Another type of optical pyrometer much used for certain purposes is that known in America as the Morse and in Germany as the Holborn-Kurlbaum instrument. In the latter of these a small incandescent lamp with a plain horseshoe filament is placed at the focal-point of a short-focus telescope, sighted upon the object whose temperature is to be measured. The current through the lamp is supplied from a small portable accumulator and is adjusted by a rheostat so that the bend of the filament appears equally bright with the hot background, and at this moment becomes indistinguishable from it. The magnitude of the current is then read off on a suitable deflection-ammeter, and reference to a table gives the required temperature. In the commercial forms of instrument a direct-reading temperature scale may be provided in addition to the readings of current on the ammeter, if desired. This type of instrument may be used from about 600 deg. C. upward and gives good results. The better forms are provided with several of the calibrated incandescent lamps, some of which can be reserved as reference standards, and used to check constancy of the relation between temperature and current in the working lamps. For measurements of temperatures above 1,400 deg. C. a system of mirrors forming a weakening-device is placed in the path of the light in front of the object-glass of the instrument, and by this means a second scale extending from about 1,200 deg. C. to 2,200 deg. C. is obtained, without risk of damage of the working lamps by overrunning. This type of instrument is perhaps a little easier to adjust than the others, and can be used on a small object. It and the Wanner however require accumulators, which are unnecessary with the other patterns. None of these types of "optical" as distinct from the "total radiation" pyrometer can be made to record nor can their indications conveniently be transmitted to a distance. Moreover they all involve a personal element in the setting, which is not present with the "total radiation" pyrometer.

Of the remaining available methods of measuring temperature only two need be mentioned, the calorimetric method of Siemens and that depending on the use of fusible materials as indicators, such as the well-known "cones" of Seger and the Watkin "recorders."

The calorimetric method involves the use of a cylinder of iron, copper, nickel or other metal, which is heated in the furnace whose temperature is to be measured, and then dropped quickly into a calorimeter containing a definite amount of water. The rise of temperature thus produced in the water is indicated by a thermometer; by a simple device involving a sliding scale, the temperature to which the specimen of metal was heated is obtained without calculation. This method of measurement, introduced by Sir William Siemens about forty years ago, is still used successfully in many industrial processes. Its practical upper working limit is however not much above 1,000 deg. C.

Seger cones and other similar heat recorders are used largely in pottery works, where the temperature distribution over wide areas in a large furnace needs controlling at a number of points. Usually three to six different samples of refractory mixtures of definite melting points are simultaneously exposed; from a subsequent examination of these after withdrawal from the furnace the temperature is deduced. The method is capable of giving results sufficiently accurate for many purposes, but variations in the time of exposure to the high temperature and also in the rate of heating make considerable differences in the results.

For measurements in the region above the range of the gas-thermometer (say 1,200 deg. C.) some extrapolation scale of temperature is at present the only available provisional standard. Two chief methods have up to now been employed in the establishment of such a scale. The first—the thermo-electric method—depends on the hypothesis that the formula, which represents the relation between electromotive force and temperature in a thermo-couple up to 1,200 deg. C., holds at higher ranges. The work of the National Physical Laboratory has shown that a formula of the usual parabolic type, which represents this relation very closely for almost any thermo-couple formed of the platinum metals, gives a consistent extrapolation scale up to the melting-point of platinum. On this "thermo-electric scale" the melting-point of nickel is 1,427 deg. C., that of pure iron 1,502 deg. C., and that of platinum 1,710 deg. C. It is to temperatures on this scale that the readings of couples are almost always referred.

The second extrapolation scale is based on the assumption of a definite value for the so-called constant in the Wien-Planck equation, expressing the relation between intensity of radiation and temperature. The usually accepted value for this constant is about 14,500 but it is still appreciably uncertain. On this optical scale, which should agree with the thermo-electric and gas scales at 1,200 degrees, the melting point of nickel would become about 1,450 deg. C. and that of platinum 1,750 deg. C., while the "black-body" temperature of the crater of the electric arc, which is nearly independent of the current and voltage employed, is about 3,500 deg. C.

The following is a table of the values of a number of fixed points employed in pyrometric work:

	FREEZING-POINT. Deg. Cent.
Tin	231.9
Cadmium	321.0
Lead	327.4
Zinc	419.0
Antimony	631.0
Aluminium	657.0
Silver	961.0 (in reducing atmosphere)
Copper	1,083.0 (in reducing atmosphere)
Gold	1,082.0
Nickel	1,417.0 (thermo-electric) 1,450.0 (opt.)
Platinum	1,710.0 (thermo-electric) 1,750.0 (opt.)

Earth Connections.—The only effective method of obtaining a good earth connection is to rely primarily, at any rate, upon a surface earthing system placed in carefully chosen surroundings. Local earth plates underground have so often been known to fail that they are now commonly regarded, and justifiably, as not sufficiently reliable for their purpose. With regard to earth connections to motor frames, switch cases, etc., the difficulty which here arises is largely a personal one. An inexperienced man would not be allowed to set a safety valve, but "earthing" is frequently allowed to be carried out by unskilled workmen, some of whom are careless and very few of whom understand the aim and object of an earth connection. The result is that a great number of earth connections which are made are ineffective. Both the points above mentioned are of primary importance from a safety standpoint.—*The Engineer.*

Engineering Notes.

Water Leakage in Turbines.—The leakage of circulating water into the tubes of a condenser has little effect on the steam consumption of the turbine unit, but going directly into the hot well along with the water obtained by condensation, it may be of such an amount as to change an otherwise soft and neutral hot-well supply into a highly alkaline and undesirable boiler feed water. At one of the stations in America it is customary to make frequent alkalinity tests upon the condensation of each unit, thus detecting the slightest leaks and remedying them before they become serious.—*The Engineer.*

Heat Loss in Machinery.—The heat developed by machinery in motion is sometimes considerable, as indicated in some figures collected by the committee appointed by the Home Secretary of State to investigate conditions in cotton mills. The average amount of heat given up by the looms in three weaving sheds on a cloudy day was about 62 per cent of the total generated in each shed. The amount of heat emitted by the operatives averaged about 21 per cent, and the amount of heat radiated from steam pipes amounted to about 17 per cent. To determine the effect of sunshine on the temperature, observations were taken in a number of sheds of the rise in temperature between 6 A. M. and 5.30 P. M. on both cloudy and sunny days, and it was found that the average increase due to the sun was 38 per cent.—*The Engineer.*

The Efficiency of the Lathe as a Chip Producer.—In a paper entitled "Some Notes on the Speed and Power of Machine Tools," read before the North-East Coast Institution of Engineers and Shipbuilders, Mr. Joseph Chilton states that "as a chip producer the lathe is the most economical of machine tools. A well designed lathe, working under favorable conditions, produces ½ pound of chips per horse-power minute when cutting mild steel. The pressure on a lathe tool when cutting mild steel is approximately 100 tons per square inch area of cut, the area of cut being depth multiplied by feed, i. e., a cut ½ inch deep by ¼ inch feed has an area of 1/16 square inch. When cutting cast iron the pressure is about 50 tons per square inch, consequently about one pound of cast iron should be removed per horse-power minute."—*The Engineer.*

The Uneven Settlement of a Tall Building.—Uneven settling of a tall building on a floating foundation in Chicago has caused the building department of that city some apprehension, particularly on account of the fact that the columns are of cast iron. The Unity Building is sixteen stories high, was erected in 1891, rests on a grillage of I-beams 30 to 40 feet below street grade, and has settled 9 inches more on the south side alongside an alley than on the other side adjacent to lower structures. The uneven settlement has thrown the top 30 inches out of plumb. On June 10th, 1910, records indicated the building was 13¾ inches out of plumb at the twelfth floor. Levels five days apart, beginning August 14th, showed a slight settlement, but for the next ten days little movement was detected. While the building commissioner, Mr. Henry Ericsson, says he does not believe there is any immediate danger, he had an investigation made by Messrs. E. C. Shankland, Louis Ritter and Karl L. Lehman, who reported that the building was not in a safe condition. In consequence the owners were notified by the building department that the building was in such an unsafe condition as to endanger life, but by the immediate application of precautionary measures danger might be averted. Such measures were ordered put into effect as would place the building in a safe condition. Arrangements have already been made by the owners to straighten the building.—*Engineering Record.*

TABLE OF CONTENTS